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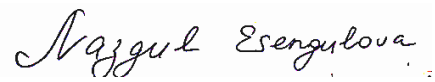

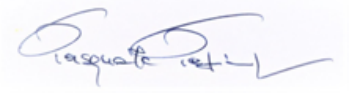

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Chapter 1

General Introduction

1.1 Background

Place-based approaches and region-specific, tailored solutions can make a tangible positive change toward sustainable regional development in peripheral, marginalised rural areas. These strategies promote resilience and empowerment by leveraging regional assets and engaging local communities [1]. Particularly, this is important in areas distinguished by significant biological, cultural, and geological diversity. To ensure positive impact and success, these initiatives should be grounded in local stakeholders' needs, perspectives, and visions [2],[3]

Gargano is a rural peripheral area in the Southern region of Italy, characterised by persistent socio-economic challenges, environmental degradation, outmigration, and low levels of community engagement, representative of the challenges often faced by similar areas within the Puglia Province and the south of Italy as a whole. However, what sets Gargano apart from other similar areas is its extraordinary status as a biodiversity hotspot [4], [5] Gargano contains 35% of all Italian botanical species, its olive and citrus orchards still preserve ancient cultivars of olive and citrus[6] These traditional varieties have been an integral part of the area's economy, culture, and diet, deeply rooted in Mediterranean traditions. It has nationally and internationally important geological diversity[7] As such, there is a need for cohesive place-based development strategies that encompass not only economic growth but also environmental stewardship and social inclusion to boost sustainable development in this lagging behind territory.

Designing development strategies, especially for rural areas, often involves analysis of Land Use and Land Cover (LULC) changes [8] as they evident indicators of rural transformations. Considering that patterns of natural resource use, including changes in land use and land cover are the result of intricate interactions between people, economy, culture, and the environment [9], [10], there is a need to deepen the study of this dimension in a complex manner which examines human societies and ecosystems as two parts of one phenomenon.

Social-ecological system (SES) is one of such approaches that investigates human-nature interplay and argues that all elements within this complex SES constantly interact, producing a dynamic loop of feedback, has an internal hierarchical structure and is self-organised [11],[12].
The SES framework helps to identify risks and possibilities for resilience development through the evaluation of these interactions. It highlights the need for collaborative and tailored strategies that prioritise local potential and empower people to actively engage in shaping their futures.

UNESCO Global Geopark (UGGP) model exemplifies the practical application of SES principles. Geoparks are sites specially designated to showcase important geological heritage and promote sustainable development. They achieve this by integrating economic, educational, and conservation programs that benefit the local community [13] UNESCO. Geoparks are places where sustainable tourism makes use of the area's varied geology and artisanal industries and generates new revenue streams while protecting irreplaceable cultural and ecological treasures. The UGGP model is particularly appropriate for marginalised communities because of its emphasis on community engagement and participatory government.

The enduring impact of UGGP mostly relies on local support [14];[15];[16];[17];[18]. Therefore, a bottom-up approach is a primary requirement for the establishment of UNESCO Geopark and community involvement is crucial in all stages of its operation as set forward by the UNESCO [13]. Indeed, the success and long-term sustainability of Geoparks is dependent on more than just the

ecological and economic benefits that they produce, but also predominantly on the support of local people.

Understanding how local stakeholders perceive and value the geopark's benefits is vital for its long-term sustainability.

1.2 Objective of the thesis:

The objective of this research is to assess the implementation of the UGGP model in the Gargano area as a potential development strategy and, it seeks to evaluate the degree of its social acceptability among local stakeholders. The analysis is guided by the hypothesis: Local stakeholders exhibit a limited understanding of UGGP and its contribution to sustainable development, consequently, they demonstrate a lack of support for the UGGP model.

The study was guided by two primary research questions:

RQ1: To what extent are the elements of the UGGP model perceived by local stakeholders as potential drivers for local sustainable development?
RQ2: What actions can be implemented to foster the social acceptability of the UGGP model as a strategic framework for sustainable development in the area, as perceived by local stakeholders?

To investigate these questions, a combined methodological approach was employed, including a SWOT-SOR experiment with local stakeholders and Fuzzy Cognitive Maps (FCM) to analyze their perceptions. These methods provided a nuanced understanding of how stakeholders viewed the UGGP model and its applicability to the region.

To effectively address RQ1 and RQ2**,** it was first necessary to identify the key actors whose opinions strongly influence decision-making and the design of development strategies in Gargano.

This led to the formulation of an additional research question:

RQ3: Who are the key stakeholders that influence decision-making and development strategies in Gargano?

This question was answered through a comprehensive stakeholder analysis, which is discussed in detail in Chapter 2. The analysis identified individuals and groups who are influential in decision-making and design of development strategies.

To analyse potential sustainable development strategies for Gargano, it was also important to examine the region's development patterns and its characteristics as a SES. Gargano, being a predominantly rural and agricultural area with a significant portion of its territory designated as a National Park, warranted a detailed investigation of its Land Use and Land Cover (LULC) changes.

This led to the development of another research question:

RQ4: What are the major LULC transformations in Gargano, and what are the key drivers of these changes?

This question was addressed through an analysis of LULC changes, providing insights into the transformations shaping Gargano SES and the factors driving these changes.

Answering RQ3 and RQ4 ensured a solid foundation for subsequent analyses and informed the study's overall approach to addressing its core research questions.

Existing literature often puts emphasis on the theoretical and institutional dimensions of the UGGP model, underestimating the study of how local stakeholders perceive its components as drivers for sustainable development. This gap hinders the efficient implementation of the model, particularly in marginalised areas like Gargano.

Although the UGGP model has been implemented in many countries, there is a lack of research about strategies to improve its social acceptability among local people, particularly in specific socio-ecological systems as Gargano.

Although SWOT and Fuzzy Cognitive Maps (FCMs) are established tools, their integrated use to evaluate stakeholder perceptions of UGGP as a sustainable development strategy is seldom recorded. This reveals a methodological gap that this research seeks to address.

Integrating LULC analysis into the research adds a spatial and environmental aspect, correlating changes in land use patterns with perceptions of sustainable development strategies.

The study enhances academic discourse on sustainable development frameworks. Findings offer practical recommendations to align UGGP initiatives with local priorities, fostering sustainable and inclusive development.

1.3 Structure of the Thesis

The remainder of the thesis consists of three research chapters, each designed to fulfill the aforementioned study objectives (Chapters 2-4), followed by a concluding chapter.

Chapter 2 analyses the research question 3 Who are the key stakeholders that influence decision-making and development strategies in Gargano?

Chapter 3 answers the research question 4 the major LULC transformations in Gargano, and what are the key drivers of these changes?

Chapter 4 based on findings from previous chapters this chapter answers the main research objectives of the whole research. Namely, to what extent are the elements of the UGGP model perceived by local stakeholders as potential drivers for local sustainable development?,

and what actions can be implemented to foster the social acceptability of the UGGP model as a strategic framework for sustainable development in the area, as perceived by local stakeholders?

Chapter 5 offers the overarching conclusion of this research, synthesizing the principal results of the thesis while emphasizing limits and prospective research avenues.

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Chapter 2

Stakeholder Empowerment in Sustainable Rural Development Partnerships: Two Case Studies from Italy

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Stakeholder Empowerment in Sustainable Rural Development Partnerships: Two Case Studies from Italy

Abstract

The funds allocated through the EU Rural Development Programme provided the engine for local stakeholders to interact, forming mixed collaboration partnerships. This paper investigates the structure of such partnerships to verify whether (R1) there are significant differences between the various stakeholder categories in influencing the rural development process, and (R2) which categories of stakeholders are more empowered in directing the design of sustainable rural development. The study is focused on two Italian cases: the regions of Apulia and Veneto. Using a combination of SNA and nonparametric tests, the results demonstrate that the empowerment of the stakeholders followed unequal paths in the two cases; i.e., a central role is clearly played by economic associations in Apulia, while this power is more distributed between different kinds of stakeholders in the case of Veneto. Agricultural associations in Apulia play an important role in the densely connected rural development network, promoting information flow and collective action. On the other hand, the weakness of this configuration lies in the fact that the rural development agenda can receive strong pressure from the agricultural sector, pushing more sectoral strategies in turn. Private companies play a key role in Veneto's rural development, bridging the network gaps between more clustered local groups and increasing pluralism and inclusion. However, the network is sparse and shrinking, posing challenges in terms of coordination and collective action. This kind of evaluation makes policymakers and managers aware of both the most influential and weakest actors. This is crucial to improving the effectiveness and sustainability of the project, as they can involve the most influential groups from the early stages of the design process to ensure support as well as address the needs of the lagging stakeholder categories to reinforce tacit rules, trust, accountability, and responsibilities.

Keywords: local partnership models; stakeholder categories; empowerment; sustainable rural development; social network analysis

1. Introduction

Bottom-up or endogenous approaches have been the reference model for rural development in the EU since the early 1990s with the LEADER Initiative. The bottom-up approach implies that local actors participate in decision-making about a strategy and in the selection of the priorities to be pursued in their local area. The involvement of local actors includes the population at large, economic and social interest groups, and representatives of public and private institutions in upholding cultural, social, political, and ecological values and the possible assessment of social costs and long-term effects [1].Five editions of the LEADER Initiative have been implemented over the past 30 years, with improved schemes based on previous experience. They have been consolidated with Community-Led Local Development (CLLD). Although this approach is mostly focused on qualitative and structural interventions rather than just using quantitative and monetary measures as criteria to assess its success [2], EUR 19.81 billion has been allocated through this programme for rural development in the period of 1991–2020 to give local communities the means to develop their potential and their territories [3]. LEADER Initiatives beneficiaries have made investments that raised the living standards of their territories, enriched rural life, and improved physical infrastructure and tourist attractiveness as a result of protecting their rural environment and cultural heritage [4].The idea underlying the bottom-up approach is that local people are the best experts in the development of their territories. The co-design of a development project can increase stakeholders' self-awareness, the ability to develop a shared vision, and the capacity to generate novel ideas and produce value-adding initiatives, eventually benefiting the region as a whole [5] In this vein, Li et al. [6] highlight that rural development is strongly shaped by the ability of the community to efficiently respond to external changes. In this regard, for sustainable rural development, it is important to strengthen the internal capacities of the communities that represent their resilience potential. This enables communities to withstand any external influence and even unexpected shocks.The European Network for Rural Development conceives

the LEADER Initiative as a participatory democracy tool, and the allocated funds provide the engine for stakeholder interactions [7]. This is a source of another crucial endogenous resource: community social capital. When the social capital of a group is increased, cooperation is, in turn, positively influenced. Thus, social capital changes the cost–benefit ratio for individuals and mitigates the problem of possible free-riding in policy programs [8]. The practice of rural development partnership not only empowers people and strengthens local capacity but also develops peoples system thinking skills. System thinking skills or big picture thinking mean that people see the complex picture of the issue and comprehend the interdependence and interconnectedness of various components comprising the issue. This skill helps to better navigate complexity and find efficient solutions for a sustainable future [9–11].Moreover, as rural development partnerships are multi-stakeholder in nature, the main goal is to create a win–win scenario for all parties involved, where they combine their resources and skills to successfully address shared social or environmental goals [12–15].The definition of partnership differs in the literature depending on its purpose, the actors involved, the stage of development, the spatial dimension, and the implementation mechanisms [16]. Here, we refer to a territory-based concept of partnership, as defined by Biderman et al. [17], which characterises formal long-term collaborations between governmental, corporate, and volunteer organisations who agree to share responsibilities, risks, costs, and benefits in achieving shared goals in a particular geographic location. This process involves a combination of consultation, negotiations, and bargaining, heavily dependent on a shared vision and on the ability to identify appropriate trade-offs both between and within interest groups [18].With respect to their origins, local partnerships in EU rural developments relate to three approaches. Local partnerships are created (i) by individuals, often “local leaders”, who would like to actively intervene in the local reality, not only economically but also socially and culturally; (ii) by businesses that claim a privileged position in economic decisions; (iii) and by public authorities, which can compensate for a rare or failing private initiative in problem areas. The nature of the process and outcomes are, therefore, different for each of the three cases [19].Within the context of LEADER, a partnership is considered the formation of a network of relationships and solidarity at the level of a certain rural area, called a Local Action Group (LAG). Often it

is expected to be more than just joint economic activity; rather, it may be a local entity representing a will to build a social identity [5].Following the introduction and implementation of the first edition of LEADER, rural partnerships created over the course of this initiative have been scrutinised from many perspectives by numerous scholars in different European countries, including new member states and post-socialist countries [4,20–27]. Some of them have emphasised the programme's beneficial influence [4,28,29], while others have criticised it and suggested improvements [8,21,24,30,31] Ray describes the LEADER Programme as contributing to rural development, as it initiated many local-level projects. Hoffman and Hoffman [4] mention the positive impact of programmes that have built strong social and human capital and cooperation skills and improved the level of living and the quality of life in the countryside. Esparcia [28], although acknowledging the overall positive impact of the programme, note that it has certain institutional and structural issues that prevent the wider community from being involved in and benefiting from it: "LEADER has become a political, social and economic instrument" [28]. Similar arguments are put forward by Navarro et al., who point out that actively involved stakeholders mainly represent those who have the time, resources, and aspirations to take part, notably, local elites. The poor and other disadvantaged groups remain marginalised (Navarro et al., 2015) [24].Most scholars agreed that the nature and degree of partnership vary significantly depending on the characteristics of each country, such as the political regime, the degree of government centralisation, the strength of civil society and local participation, and the presence of a strong tradition of cooperation.Mosley et al. [21] provide a comprehensive examination of 24 case studies across several European countries. According to this research, common factors serving to improve or weaken partnerships in rural development have been observed.

Among the positive ones, there is the existence of coherent and relevant aims based on the recognition of common needs, strong but not over-dominant leadership, good administration and technical support, good user-friendly communication, the early achievement of visible benefits, mutual trust, the equal participation of parties in the decision-making process, well-developed informal networking, and others. Among the constraints for successful partnerships were the stated

centralisation of decision-making, the dominance of a certain small group of stakeholders, limited financial resources, excessive bureaucracy, short time perspectives of development programmes, and others.

Since the predominant sector in rural areas is still agriculture, most studies focus on this sector. In this regard, research carried out by Guerrero-Ocampo [27] presents a special interest. He investigated the social structures of multi-actor partnerships involved in interactive innovation processes in agricultural innovation systems. The results of 17 case studies that he examined based on social network analysis (SNA) and descriptive statistics show that the composition of the innovation networks is diverse, but when the frequency of connections is examined, there is a tendency to develop more interactions between organisations of the same type. Farmers and research institutions are critical members in the "core" of innovation networks.

Despite the abundance of research analysing the LEADER Programme, its structural specifics, and contributing role of LAGs in the growth of cooperation in rural areas, there has been little discussion at a deeper level focusing on the very structure of partnerships concerning how partnerships are formed, how stakeholders are connected, who are the most influential ones, and how decisions are made in their networks.

This paper provides a contribution in this direction, as it investigates, with respect to two territorial case studies, whether there are (R1) significant differences between the various stakeholder categories in influencing rural development partnerships and (R2) which categories of stakeholders are more empowered in directing the process of sustainable rural development. To study these aspects, we adopted an analytical approach based on SNA to investigate the Italian case. Italy is a country that has been dealing with partnership formation in a rural context since the very first edition of the LEADER Initiative. These cases relate to two major agricultural regions, namely, Veneto and Apulia.

Section 2 illustrates the materials and methods employed. It focuses on case studies, a review of the stakeholder categories, and the analytical approach used. In Section 3, the results of the analysis are presented. Section 4 returns to the research question and provides several policy implications

and some concluding remarks.

2. Materials and Methods

2.1 Case Study Regions

Our work is focused on the Veneto and Apulia regions, two Italian territorial ad- ministrative units. These two regions were selected based on several factors: distinct geographical locations, climatic differences, ecological specifics, and economic and social contrasts. Veneto is considered one of the most developed regions of Italy, whereas Puglia is still lagging behind. For the purposes of its convergence objective, the EU Rural De- velopment Scheme has distributed greater financial resources to the Apulia region in the implementation of the LEADER Programme. A specific focus on these two territories is provided in what follows.

Apulia Region. This region is located in the southeast of Italy; it is the 7th region in terms of area (19k Km2) and population (+4 million). According to the Italian National Institute of Statistics (ISTAT), Apulia can be classified as a lagging-behind region. Its GDP accounts for EUR 69.5 billion. Its economy has a strong agricultural tradition, and this sector contributes 3.6% to the regional GDP. The key agricultural products are wheat, olive oil, and vegetables. These products are crucial in the Apulian export balance, which has accounted for +11% since 2008.

A large number of traditional products are presented, which are included in MIPAAF (Italian Ministry of Agriculture, Food, and Forestry Policies), and Slow Food does represent a valuable resource in promoting the overall area and its local production [32]. Strong growth in the service sector accounts for 24.3% of the total GDP. Tourism contributes 3.6% of the regional GDP with EUR 9 billion. Due to its strategic position in the Mediterranean basin, Apulia is well connected both externally and internally by air and by sea, with 10 airports, 12 commercial and civil major ports in the region, and another 34 touristic ports. The rail network is the least developed infrastructure network in the Puglia region at 20% below the Italian average. The Apulia region is part of the Natura2000 EU Network, with 21% of its total area, 92 sites, 44 habitats, 90 bird species, and 81 species of EU interest. In

Apulia, there are 4 UNESCO-designated sites. The post- graduate employment rate is 37.1% below both the South Italy benchmark (42%) and Italy overall (62.8%). This metric shows how strong the brain drain phenomenon is, which could really compromise the region's future competitiveness. The 23 LAGs present in Apulia have oriented their Local Development Strategies (LDS) toward the innovation of local food, crafts, or manufacturing production systems; the development of energy supply chains; social promotion; and urban requalification, including the enhancement of cultural heritage and sustainable tourism [33].

Veneto Region. This region is located in the northeastern part of Italy. It corresponds to the most developed region category referred to in the EU Rural Area Classification of the 2014 Italian Rural Development Programme. It covers an area of 18,399 sq. km; is divided into 579 municipalities; and is 56% flat, 29% mountainous, and 15% hilly. According to the classification made by CORINE-Land-Cover 2006, there is a prevalence of agricultural lands (57.2%) and a significant portion of forested lands and/or semi-natural environments (29%), while 4% of the territory is claimed by water bodies, and 1.5% is affected by wetlands. The territory's urban and industrial infrastructure, on the other hand, accounts for 8.2% of the regional territory [32]. The main economic activities are tourism and agriculture. Un- doubtedly, the wine sector stands out in the region, and it is currently the largest producer and exporter of quality Italian wine, with almost all (91%) of protected designations of origin or geographical indications. LAGs operate in about 70 per cent of the Veneto region, within rural areas, and/or with an agricultural vocation, affecting about 35 per cent of the population. The main objectives of the LEADER Programme implementation in this region were defined as supporting participatory approaches; improving the capacities of local partnerships; promoting cooperation between territories; and stimulating the harmonious, endogenous development of rural areas [34].

2.2 Partnership Categories

For the purpose of identifying and categorising stakeholders in rural development partnerships, we employed a model presented by the LEADER Laboratory in 1997 [19]. This model

introduces three levels of classification. At the first, more general level, the stakeholders are grouped into three macro-categories based on their backgrounds and missions: (1) public institutions, (2) private companies, and (3) civic society (i.e., people or associations of people). The model further classifies these groups into a second, deeper level based on the nature of their operations, for example, the agro-food sector, the finance sector, and others. These sections have different subgroups (third level of classification) formed based on stakeholder interests. Working with this model, we have found some disparities, in particular, in the second and third levels, where some categorisations are related to the geographical specifics of stakeholders and some are based on the characteristics of stakeholder operations. To fix these issues, we modified the second and third levels, making classifications more accurate, clearer, and better suited to the rural development context. Since the present research is focused on sustainable rural development, the categorisation of partnership dimensions developed by [35] was used as a reference to elaborate our second-level classification for the purpose of coding stakeholders in our analysis. Our final classification method is reported in Table 1.

Table 1. Stakeholder categorisation method.

First Level	→	Second Level	→	Third Level
Public Institutions	→	Local Authorities	→	Town Halls Municipal Associations Regional or Territorial Government
		Public Services	→	Economic Services Social Services Research and Educational Services Infrastructural Services
		Government Agencies	→	→ Economic Agencies Environmental Agencies Other Agencies
Private Companies	→	Agro-Food Sector	→	Processing Farmers Cooperatives or Producer Organisations Union of Cooperatives
		Financial Sector	→	Bank Agricultural Mutual Savings Bank
		Other Producing Sectors	→	Business and Industrial Import–Export Other Services
Civil Society	→	Economic Associations	→	Professional Association Agricultural Association
		Social Associations	→	Labour/consumer Development Agencies Cultural Association Leisure, Sport, or Recreational Association Social or Religious Association
		Environmental Associations	→	Protection Study Use

We used the classifications presented in Table 1 as a baseline to categorise the stake- holders in our case study analysis.

2.3 SNA and Relational Data

We used SNA to analyse the ability of the various stakeholder categories to exert some kind of influence and power over rural development activities. The idea is that an important part of stakeholders' power stems from their peculiar position and connectedness in the partnership network. This is captured by some specific network indexes, as explained below in this section. To represent and analyse the collaboration interactions between the stakeholders from the regions we selected as case studies, we used a technique called the affiliation network approach. In general,

this approach allows us to pass from a two-mode network, representing the relationships between two sets of entities, called (i) *agents* and (ii) *events*, to a one-mode network that depicts the relationships between only one set of agents. A link in the two-mode network is established between the events and the agents attending those events. Finally, a link in the one-mode network is established between the agents attending the same event.

In this work, the *events* are represented by the LAGs and the *agents* by their partners.

The partnerships analysed are those in force in the programming period 2014–2020. Dur- ing the analysis of the results, it should be borne in mind that the current structure of partnerships is affected by the experience gained from previous editions of the LEADER Programme, so it reflects an evolutionary process that began with the LEADER II edition and lasted several decades.

The LAGs representing the case study were selected by identifying, for each region, a convenient area formed by many neighbouring municipalities, characterised by the high presence of rural development projects. The data used to obtain the affiliation networks were collected based on the documentation retrieved from the official websites of the selected LAGs. We surfed these web resources to collect the documents reporting the partnerships of each LAG. This allowed us to build two affiliation networks, one for each region. Moreover, we searched for information on the activity of each partner to identify its stakeholder category according to the classification provided in the previous section. For the purposes of this analysis, we grouped the stakeholders into five main categories: (i) public institutions, (ii) the agro-food sector, (iii) other producing sectors, (iv) economic associations, and (v) social associations.

The networks were then analysed using network and punctual indexes [36]. The former, along with a visual representation, allowed us to grasp information on the whole web of stakeholder collaborations. We employed some indexes as the number of nodes and connections, the density (i.e., the between the number of actual connections and the maximum number of possible connections), the centralisation index (i.e., the sum of differences between the degree of the most central node and the degrees of all other nodes, divided by the largest theoretical sum; this reflects the extent to which the network is characterised by the presence of one or more very

central nodes), the average degree (i.e., the sum of the degrees of all stakeholders divided by the number of stakeholders in the network), and the average distance (i.e., the average number of steps along the shortest paths for all possible pairs of network nodes).

Moreover, we used four punctual indices to measure various aspects of stakeholder power derived from their peculiar position and connectedness in the network. These measures are briefly summarised below.

Degree centrality. This is the number of connections the stakeholder has with others and accounts for a relevant positional advantage, proving that a stakeholder with many connections can directly influence the resources that flow through the network and hold these resources without intermediation.

Betweenness centrality. Another aspect of power arising from the network position relates to the possibility of a stakeholder acting as an intermediary between the others. The betweenness centrality is a measure of this brokerage role of the stakeholder. as it is the sum of links connecting other stakeholders passing through himself [37].

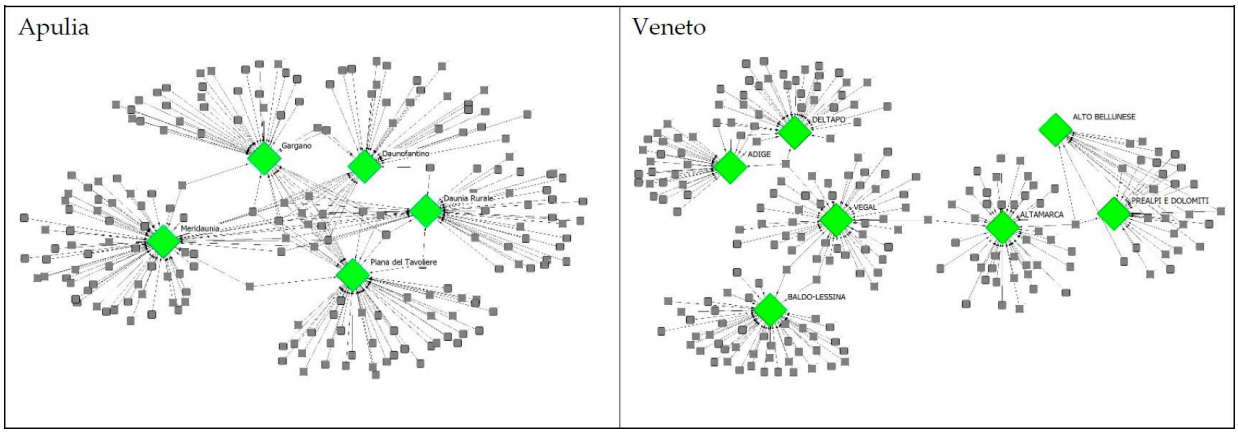
Closeness centrality. This is simply the reciprocal of the farness of a given node, where the farness is the sum of the lengths of the shortest paths to every other node. The ratio of this index lies in the fact that the closer a stakeholder is to all the others, the higher its influence is likely to be.

Eigenvector. This is a more refined measure of closeness, as it is calculated using a factor identifying the "components" of distances among actors. The first component accounts for the "global" distance between stakeholders rather than the immediate closeness [37].

We treated these measures using statistical nonparametric procedures in order to verify if significant differences exist in the amount of power belonging to the various categories of stakeholders. Following [38], two tests were implemented. The Kruskal– Wallis H test was employed to verify whether a global difference between the stakeholders' centrality measures arises overall. The Mann–Whitney U test was performed to assess which inter-stakeholder categories are significantly different in the centrality measures.

3. Results

Based on the case study identification explained in Section 2, in our investigation, we considered five LAGs of the Apulia region—namely, Gargano, Daunofantino, Daunia Rurale, Piana del Tavoliere, and Meridaunia—and seven for the Veneto case—specifically, Delta Po, Adige, Vegal, Baldo Lessina, Alta Marca, and Prealpi Dolomiti. Figures 1 and 2 represent, respectively, the affiliation networks and the derived one-mode networks of the case studies.



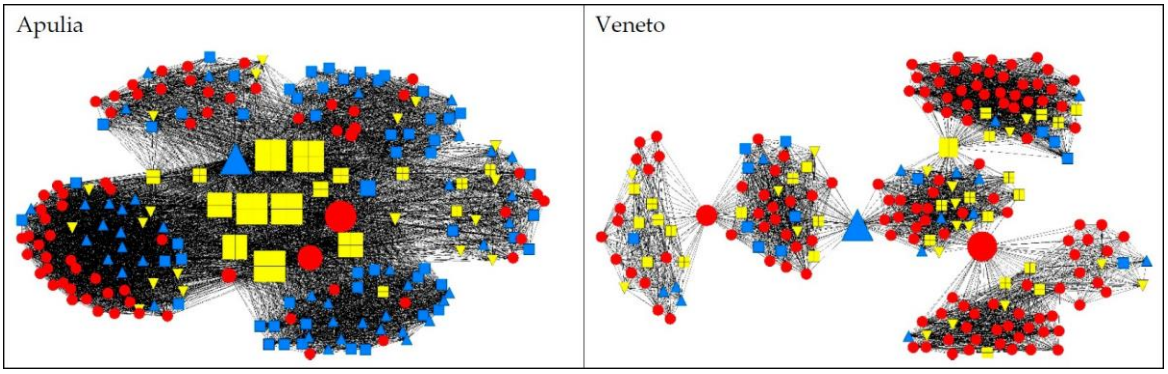


Figure 2. Rural development one-mode networks in the two case studies. Legend: colours represent stakeholder sectors (red = public; blue = private; yellow = civic society); shapes represent stakeholder categories (circle = public institutions; square = agro-food sector; up triangle = other producing sectors; box = economic associations; down triangle = social associations); size represents the degree centrality (the greater the size, the higher the degree centrality).

The partnerships are formed by 202 and 235 stakeholders, respectively, in the Apulia and Veneto cases. Table 2 helps in identifying some key features. The most represented category in both cases is public institutions. It represents most of the stakeholders (66%) in Veneto. Moreover, the private sector (agro-food and other producing sectors) is well represented (26% and 21%) in the Apulia region, while it is less represented in Veneto. Finally, the economic association is the least represented sector in Apulia. In general, the representativeness is more balanced in Apulia than in Veneto.

Apart from this first descriptive analysis, the visual representation reveals that, though it is underrepresented in the Apulia region, the economic association category exhibits high centrality, and several actors from this category bridge structural holes between the various parts of the network. At the same time, two public institutions and a private company also show the same characteristics. In the case of Veneto, this bridging role is played by four major actors, two public institutions, a private company, and an economic association, with four poles formed of town halls and other actors gravitating around them.

Table 2 summarises other key characteristics, showing higher connectivity in the case of Apulia (which outperforms the Veneto network in all the network indexes). In particular, the density of the network reaches 32% in all the possible connections. This index is also rather high in the case of Veneto, as it tops out at 19%. Moreover, the network of the Apulia region is highly centralised (69%), signaling that there are only a few actors collecting the majority of all the existing connections.

Table 2. Network metrics of the two case studies.

Metrics	Apulia	Veneto
No. of nodes	202	235
Public Institutions	69 (0.34)	156 (0.66)
Agro-Food Sector	54 (0.26)	16 (0.07)
Other Producing Sectors	43 (0.21)	15 (0.06)
Economic Associations	17 (0.08)	29 (0.12)
Social Associations	19 (0.09)	19 (0.08)

No. of ties	12,944	10,186
Avg. Degree	64.08	43.34
Deg. Centralisation	0.69	0.28
Density	0.32	0.19
Avg. Distance	1.68	2.40

Figure 3 reports the average centrality measures of each stakeholder category. It sup- ports the initial hint suggested by the visual representation related to the high connectivity of the economic association category in the case of the Apulia region. This category seems to be the most central with respect to the other measures. This difference appears to be at its highest in the case of betweenness. The Apulia network is also highly connected, and this is reflected in the high closeness of all the stakeholder categories. Apart from the economic associations, another strong category is represented by the public institutions as it shows high eigenvector. In the case of Veneto, the centrality seems more equally distributed between the stakeholder categories, as anticipated by the lower centralisation measure (29%) reported in Table 1. However, in terms of betweenness, an important role is played both by the public institutions and the other producing sectors. On the other side, economic associations and the agro-food sector have the highest degree of centrality in the mean.

To test if these remarkable positions depend on a significant difference in the centrality of the different stakeholder categories, we performed the Kruskal–Wallis H test (Table 3). It revealed that there is a significant difference in all the centrality measures in the case of Apulia (significant at the 99% level) and in all except the betweenness in the case of Veneto (significant at the 95% level). In order to identify the sources of these differences, a pairwise comparison was performed employing the Mann–Whitney U test (Table 4).

Table 3. Kruskal–Wallis H test of differences in the centrality measures of stakeholder categories.

Centrality Measures	Apulia	Veneto
Degree	0.00017 ***	0.02548 **
Betweenness	0.00005 ***	0.08206
Closeness	0.00033 ***	0.04726 **
Eigenvector	0.00175 ***	0.01853 **

** Significant at the 95% level; *** significant at the 99% level.

Table 4. Mann–Whitney U test of differences in the centrality measures between stakeholder categories.

	Apulia				Veneto			
Pairwise Comparison	**Degree**	**Betweenness**	**Closeness**	**Eigenvector**	**Degree**	**Betweenness**	**Closeness**	**Eigenvector**
Pub-Agr	0.02088 **	0.61006	0.02382 **	0.02444 **	0.0394 **	0.23404	0.02202 **	0.01046 **
Pub-Pro	0.4009	0.67448	0.50286	0.63122	0.28014	0.4654	0.03156 **	0.02382
Pub-Eco	0.00036 ***	<0.00001 ***	0.00072 ***	0.01174 **	0.01552 **	0.30772	0.00988 **	0.00244 ***
Pub-Soc	0.30302	0.89656	0.3843	0.23404	0.37886	0.20766	0.04136 **	0.0455 **
Agr-Pro	0.0251 **	0.9681	0.0251 **	0.01878 **	0.06576	0.76418	0.59612	0.72786
Agr-Eco	0.00012 ***	<0.00001 ***	0.00016 ***	0.0003 ***	0.8493	0.02382 **	0.77948	0.96012
Agr-Soc	0.83366	0.83366	0.83366	0.81034	0.0164 **	0.98404	0.96012	0.61006
Pro-Eco	0.0005 ***	<0.00001 ***	0.0008 ***	0.00544 ***	0.15854	0.08726	0.76418	0.92034
Pro-Soc	0.67448	<0.00001 ***	0.67448	0.5287	0.77948	0.75656	0.67448	0.53526
Eco-Soc	0.00128 ***	0.00012 ***	0.002 ***	0.0139 **	0.0477 **	0.01684 **	0.98404	0.5552

** Significant at the 95% level; *** significant at the 99% level. Legend: Pub = public institutions, Agr = agro-food, Pro = other producing sectors, Eco = economic associations, Soc = social and environmental associations.

As shown, there are significant differences between several pairs of stakeholder cat- egories in both case studies. In the case of Apulia, these pairs are (1) public institutions and agro-food companies; (2) public institutions and economic associations; (3) agro-food and other producing sectors; (4) agro-food and economic associations; (5) other producing sectors and economic associations; (6) other producing sectors and social associations; (7) and economic associations and social associations.

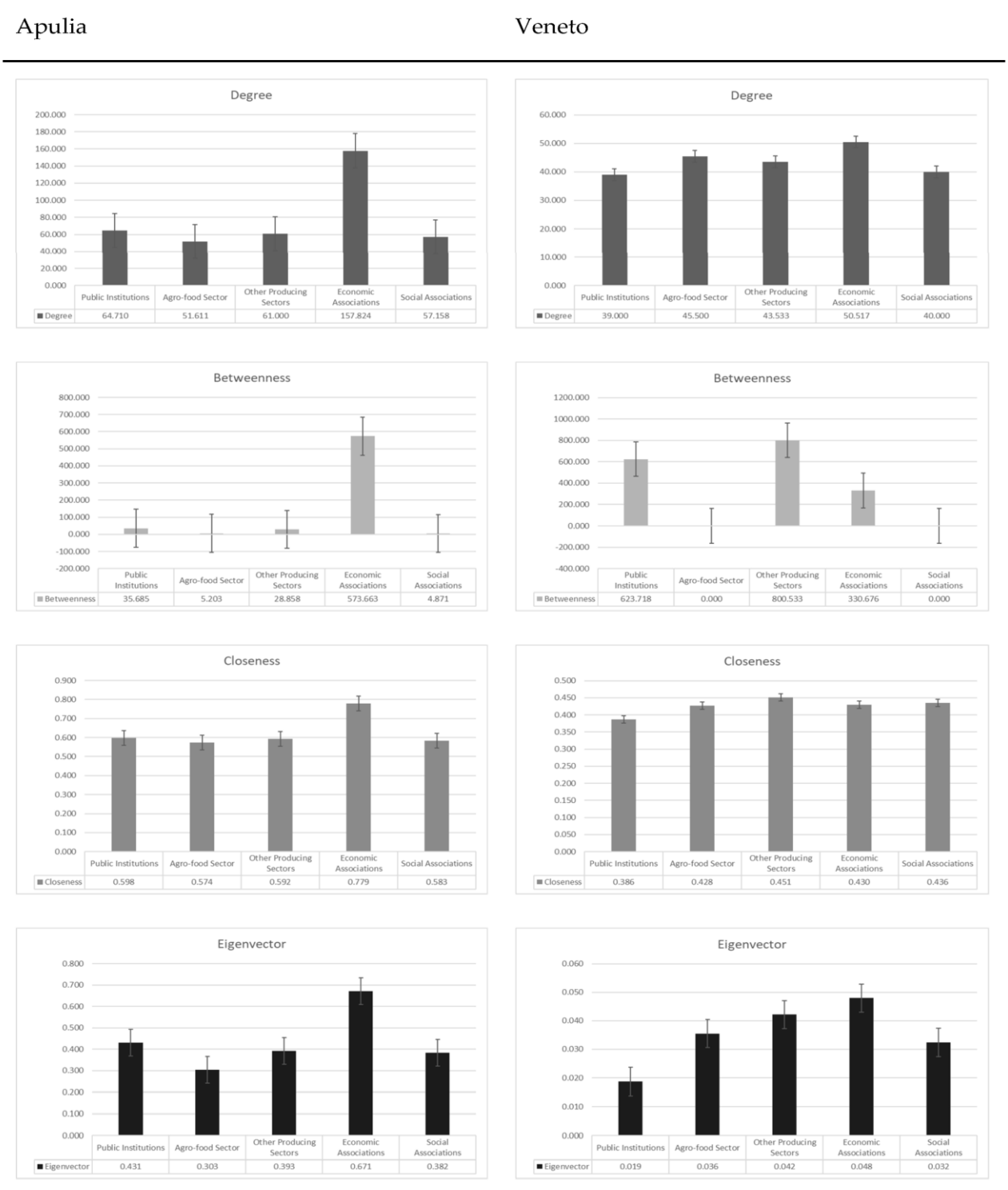
In the case of Veneto, these pairs are (1) public institutions and agro-food companies; (2) public institutions and other producing sectors; (3) public institutions and economic associations; (4) public institutions and social associations; (5) agro-food and economic associations; (6) agro-food and social associations; and (7) economic associations and social associations.

In the case of Apulia, the empowerment of the economic associations category is confirmed. It significantly outperformed all the other categories in all the indicators. This means that the stakeholders belonging to this category are able to directly govern the flow of information between the other stakeholders, play a high brokerage role, and are close to all other partners in general, covering all the dimensions of power accounted for by the network indexes used for this analysis. Surprisingly, the most marginalised category in this area is represented by the agro-food sector,

which is systematically subject to the power of the other categories. This means that the stakeholders in this category depend on others, especially economic associations, to gain relevant information related to rural development and need to use their brokerage role to obtain distant partners. Another weak position is covered by the stakeholders of the social and environmental associations, which are in marginal positions in the network.

In the case of Veneto, the power distribution is more balanced. In particular, and also in this region, economic associations play a significant networking role, but the actors from this category are not always essential for the other actors to interact and receive information, as other private stakeholders, both from the agro-food and other producing sectors, can serve as connecting hubs. In this case, the most marginalised category is represented by public institutions. This is due to the fact that the majority of the public institutions in the Veneto LAGs are municipalities, which, because of their territorial competencies, belong to only one LAG. This means that this kind of actor remains locally focused and has little influence outside its territory.

Figure 3. Average centrality measures for the two case studies.



4. Discussion and Conclusions

The aim of this work was to contribute to the analysis of the formation and structure of partnerships formed to implement rural development plans in the context of EU agricultural policies. In particular, the analysis was focused on two case studies, which were used to verify the existence of practical disparities in the empowerment of diverse stakeholder categories.

The analysis presented confirmed that the empowerment of the stakeholders follows unequal paths (R1). This is due to the fact that, depending on the LAG's context, some categories assume central roles in connecting other partners. While some categories, such as town halls, have very local natures and belong to only one LAG, others play a coordination role beyond the territorial LAG boundaries. The main difference between the two cases investigated is that this central role is clearly played by the economic associations in Apulia, whereas this power is more evenly distributed among different kinds of stakeholders in the case of Veneto. This also reflects the centralisation characteristics of the two networks, as the Apulia results were highly centralised (R2).

Going more in-depth, the influence of the economic associations in Apulia relates mainly to agricultural associations, which are in almost all the groups. Their fundamental mission is to support and represent farmers to ensure their participation in the formulation and implementation of agricultural development policies and actions. Their central role in the Apulia region stems from both historical and territorial characteristics. From a historical perspective, the aggregation of farmers is a long-term process that went through alternating phases of restructuring agricultural organisations between profitable and ef- efficient professional units, freely managed by farmers, and new types of organisations directed at representing farmers in decision-making contexts. From the territorial point of view, the super-representativeness of the agricultural associations arises from the fact that, being a lagging-behind region, Apulia is still an agriculture-based economy with many entrepreneurial resources within the primary sector. The representative role of the agricultural association in this region represents a strength in the extent to which these cooperation bodies play an umbrella role, providing valuable coordination activity in a densely connected rural development

network and promoting information flow and collec- tive action. On the other hand, the weakness of this configuration lies in the fact that the rural development agenda can receive strong pressure from the agricultural sector, pushing more sectoral strategies in turn. This poses a possible risk to the social sustainability of the development strategies that, according to CLLD principles, should prioritise a complex approach focused on the balanced valorisation of endogenous territorial resources in an interconnected fashion.

In the case of Veneto, representativeness is shared between diverse categories of stakeholders. Private companies play a brokerage function, bridging the network holes between more clustered local groups. This is due to the more advanced economy and brings some interesting opportunities for increasing pluralism and inclusion as more agents become active in decision-making; this contributes to a more comprehensive rural development agenda and eases the problem-solving process as more diverse resources are pulled together. On the other hand, the network is sparser and shrinking, posing possible challenges in terms of extended coordination and collective action.

This analysis has shown that partnership configurations can be very different with respect to stakeholder empowerment and that a suitable tool to reveal these differences is SNA. Indeed, it is a technique that allows for in-depth analysis of partnership compositions by deriving useful insights for policy designers. In particular, it can reveal biases even in cases of networks that seem very dense and well connected. The analysis of different aspects of power, such as those captured by the indicators used in this paper, can be useful in identifying imbalances in the distribution of power and, ultimately, in the representative- ness of interests within the partnership. In other words, even partnerships that seem well balanced in terms of the representativeness and numerosity of stakeholder categories may be unequal in terms of empowerment.

This is a valuable indication for policymakers committed to future rural development processes at higher hierarchical levels, such as the Managing Authority of the LEADER Program, represented by the Regional Administrations in the case of Italy. For such actors, it is useful to know not only who the strongest and most marginal actors are but also how unequal the power is between these categories. This power distribution can give rise to different configurations. From the analysis presented in this paper, for example, two were discovered: one in which all

the power over information brokering and control is concentrated in the hands of one category and one in which—while there is some level of inequality—several categories may play information-sorting roles.

These two configurations are very different. In the first case, actors will have only one channel available for updates. In the second case, while there is a concentration of power, there are several alternatives in terms of information channels. This obviously reduces the risk of marginalisation even when there is a disagreement between stakeholders. Policymakers also see their informational and training roles restricted in the first case rather than in the second.

This analysis also provides indications of adjustment interventions: in the case of a strong concentration of relational power, as in the case of Puglia, policymakers will necessarily have to involve the strongest category as a priority and use it to play an aggregating role. Then, they can design appropriate engagement strategies targeting the categories at the greatest risk of marginalisation. These may be differently achieved depending on the categories targeted. This action can be implemented through pilot camps and entrepreneurial visits in the case of the agri-food sector, or it can be represented by initiatives addressed to the citizens with regard to the third sector and civil associations.

In territories where the distribution of power is not as concentrated, on the other hand, it is possible to foster cross-sectoral collaborations and focus more on the involvement of the most marginalised categories in the initial phases.

Some limitations of this research relate to the fact that it analysed the structure of the partnerships but not the reasons underlying the surveyed networks' construction (e.g., trust between specific segments of the stakeholders, economic interests, informal connections, etc.). To answer these questions, a combination of approaches should be carried out, including historical analyses of past rural and agricultural local projects, in- depth interviews, and ad hoc surveys with stakeholders. Moreover, since the analysis presented was focused on the power differences between the stakeholder categories, it would be useful to refine the grain of the analysis by extending it to the assessment of power differences between actors belonging to the same category. Finally, the domain of the research could be extended by including comparisons

between European case studies.

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Chapter 3

Key Drivers of Land Use Changes in the Rural Area of Gargano (South Italy) and Their Implications for the Local Sustainable Development

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Key Drivers of Land Use Changes in the Rural Area of Gargano (South Italy) and Their Implications for the Local Sustainable Development

Abstract

This study examines the dynamics of land use and land cover change (LULCC) in the Gargano area (Southern Italy) to reveal crucial insights into the socio-economic and environmental impacts on its unique natural and cultural resources. This analysis was conducted using a mixed approach of GIS data and expert interviews to investigate significant changes in the Gargano area, from 2000 to 2018, and their drivers. Artificial surfaces gained 22% of their original surfaces, while heterogeneous areas and pastures lost 25% and 78%, respectively. Urbanization and deforestation emerged as major concerns, reflecting heightened sensitivity to these transformative processes. Agricultural intensification and support policies were perceived as potential pressure sources on specific natural components. Conversely, these drivers counteracted land abandonment. Drivers such as education level and agricultural extensification were seen as levers for a more desirable land cover dynamic. Identified actions include providing targeted support for agriculture within environmental constraints, addressing land ownership fragmentation, supporting agricultural extensification, and promoting environmental awareness.

Keywords: LULCC dynamics; Gargano; land use drivers; geospatial analysis; expert interviews

1. Introduction

Land use/land cover change (LULCC) has become a great concern in recent years worldwide, due to its adverse impacts on the environment and the consequent effect on economies and social dynamics. LULCC inhibits sustainable development [1]. An analysis of global LULCC drivers for the period of 1982–2016 carried out by Song et al. [2] states that approximately 60% of global land changes are attributed to direct human activity, with the remainder associated with indirect factors such as climate change. Changes in land use and land cover are the result of intricate interactions between people and the environment [3,4]. Hence, a complex and holistic approach incorporating both human and environmental dimensions is required for a comprehensive analysis. The identification of the key drivers of LULC changes is challenging due to the strong interdependencies and interconnectedness in socio-ecological systems (SESs) [5–7]. SESs are dynamic, and their dynamism implies that we can only identify the main drivers for a brief period of time with a need for systematic monitoring and updates. Remote sensing and a geographic information system analysis play an important role in collecting a sufficient amount of data on LULC changes [8,9].

Spatio-temporal analysis of LULCC along with on-site observations, statistics, and quantitative and qualitative data from local people and experts can provide for comprehensive research and a full picture of the ongoing and possible future scenarios, which are essential for effective decision- and policy-making targeted at sustainability in present and future times. An analysis of LULCC drivers is important for designing sustainable development strategies [10].

The scientific literature states demographic, socio-economic, institutional, technological, and biophysical factors as the main factors shaping land use and land cover change in different countries across the globe, with some of these factors prevailing more or less in certain regions depending on the specifics of the study area and the local context [11,12].

Many of these studies analyze developing countries with high rates of urbanization. Calzada et al. [13] examine land use changes in two contrasting tropical dry regions of Mexico, identifying a swift decline in natural areas due to urban expansion. A future land use simulator predicts reduced agricultural and pasture lands and increased human settlement areas by 2038. Other similar studies have analyzed LULCC in countries such as Ethiopia [14], Tanzania [15], and China [16]. These studies have identified factors such as intensive agriculture, socio-economic developments, population growth, and the quantity of exported goods as determinants of declining agricultural yield, biodiversity loss, increased aridity, land degradation, and water resource decline, exacerbating the gap in land and water supply–demand. Demographic and socio-economic factors emerged as crucial drivers in changes leading to a rise in impervious surfaces.

As argued by these studies, various approaches are employed in the analysis of the driving forces behind LULCC and landscape dynamics. Commonly, GIS and remote sensing techniques are utilized for scrutinizing LULCC changes, offering valuable insights into the spatial distribution and temporal evolution of land use patterns. An assessment of LULCC frequently involves the use of satellite imagery, such as Landsat images captured at different time points [8,14]. Landsat satellites, equipped with multispectral sensors, provide a comprehensive view of the Earth's surface, enabling the monitoring of changes in land use and land cover over specific periods. Moreover, to analyze spatiotemporal changes, some studies adopt integrated approaches like the cellular automata–artificial neural network (CAANN) methodology [17], which combines cellular automata and artificial neural networks to model and simulate complex land use dynamics, offering a comprehensive understanding of landscape transformations over time. Additionally, researchers often integrate future land use simulation models into their analyses to predict potential scenarios based on current trends and identified drivers, adopting such techniques as Dinamica [18], Markov-FLUS [19], SLEUTH cellular automata [20], artificial neural network–Markov chains [21], and CLUE-S [7]. These models serve as valuable tools for understanding and predicting the dynamics of land use across different spatial scales.

On a global basis, technological innovation, demographic change, globalization, urbanization, and

climate change are the primary determinants. These principal forces influence the demand and supply of land assets and engage in complex interactions [22,23]. The other important driving factor of land use change according to Lambin is also the history of land use [24,25], which shapes land practices. Regionally, contextual factors such as cultural preferences, biophysical characteristics, institutional arrangements, prevailing socio-economic conditions, and policy initiatives may mitigate the impacts of global drivers in rural areas and specifically in marginal territories [23]. For instance, Mack et al. [26], in their recent research, found that indirect drivers such as migration and migrant money flow of remittances have a strong impact on land systems and consequently on land change. Another study of local drivers carried out by Tahmasebi [27] suggests that, in rural areas, other often neglected factors such as psychological drivers can also have a strong impact on how land users make their decisions about land practices. Land practices and their management further create various LULCC patterns that can either be harmful or beneficial to other ecosystems [28]. This is critical if we consider areas with fragile ecosystems, which are less resistant in the face of external influence and have less ability to quickly recover from any negative disturbances and, if pushed forward beyond the threshold, would not sustain any damage. Semi-arid and arid areas are considered fragile systems (they have inherent properties of fragility). However, under increased or unpredictable disturbances caused by natural calamities or anthropogenic impact, they may demonstrate a high level of species alteration in number and composition [29–31]. Thus, designing complex, holistic land use strategies and plans is of special significance when it comes to sustainable development, in particular for inner or marginal areas where different land use types often overlap.

This task has become a major challenge, especially in the case of European countries where there exists a multilayer policy-making process along with a multi-faceted wide rural territory. To ease the designing process of tailored local development policies, a ‘place-based vision’ approach has been developed in the EU rural policy practice, as a method to favor sustainable regional development [32], in specific territorial conditions such as remote and/or marginalized regions [33]. To develop a strategic place-based vision, it is important to map the current situation in the territory, and often, this starts with mapping the natural resources at hand, the

main land use transformations, and their socio-economic determinants. The Mediterranean area has seen several transformations in recent decades, particularly driven by demographic changes leading to considerable variations in LULCC in terms of urban sprawl, abandoned rural areas, and the decrease in agricultural land [34,35]. Also, many pastoral regimes have been abandoned, thus causing an increase in natural vegetation of unfertile and unproductive land or changes in wildfire regimes [36,37]. The above changes have contributed to worsening global warming and drying climate conditions, particularly in Italy, Spain, Greece and Portugal [38].

In the context of the fragile and marginalized risky rural area of the Mediterranean basin, our analysis is focused on the micro-transformations that occurred in the area of Gargano, a mountain area in the south of Italy with semi-arid conditions and a predominantly agricultural economy [39], in the period 2000–2018.

The Gargano area (approximately 170 thousand inhabitants) relies on the key sectors of tourism, agriculture, and industry. Tourism is a major contributor to the local income, with some problems of sustainability linked to seasonality. Despite challenges like abandonment in some areas, agriculture remains crucial, with a multitude of small-scale agricultural activities taking place, particularly in olive tree and vegetable farming. However, the region faces the issue of younger generations migrating in search of better job opportunities elsewhere. The industrial sector experiences limited development, with most companies being smaller than the provincial average.

The purpose of this paper is to assess LULCC in Gargano (South Italy) and provide adequate policy recommendations based on the above transformations. The main research aims that the present study intends to pursue are (1) to identify the major LULCC transformations and (2) to investigate key drivers of these transformations.

The first question is addressed by means of a geographical information system (GIS) analysis, while the related drivers are qualitatively assessed based on the experts' views. This approach is illustrated in Section 2, which includes a focus on the case study area before introducing the GIS analysis and the method to assess the influence of drivers. In Section 3, the results of the analysis are presented. Section 4 returns to the research question and provides some policy implications and some concluding remarks.

2. Materials and Methods

The information employed in this research was collected from diverse sources: the gray literature for the socio-economic, demographic, climatic, and physiographic data of the case study area, GIS data to observe LULCC, and the scientific literature and expert interviews to identify and assess the major drivers of land use change. To ease the reading, this information has been organized into three subsections, related respectively to the case study, the LULCC analysis, and the assessment of the drivers.

2.1 Case Study Area

Gargano is a historical and geographical sub-region in Foggia, Apulia, southeast Italy, consisting of a wide isolated mountain massif and the Gargano National Park. The region is rich in culture, art, and spirituality, and 35% of all Italian botanical species can be found in the park. The climate is semi-arid, with average temperatures of around 15 ˚C, with summers between 25 ˚C and 30 ˚C, and peaks over 40 ˚C on the hottest days. Winters are relatively temperate, with temperatures not dropping below 0 ˚C.

The Gargano region is characterized by sedimentary rocks, particularly limestone and dolomites, created during the Cretaceous and Jurassic periods. The biological landscape is distinguished by its calcareous composition, karst characteristics, caves, sinkholes, and a substantial abundance of woods. The Gargano Promontory constitutes an island separated from the rest of the peninsula by the Tavoliere delle Puglie.

The study area streams are radial and hierarchical, originating from torrential sources and flowing near coastlines. Some flow into Lake Lesina and others towards Lake Varano. Inclines and rocky substrates in river valleys cause frequent flood events and long-term low water levels, transporting solid materials.

This research focuses on 13 municipalities representing more than 80% of the Gargano extension, including Cagnano Varano, Carpino, Ischitella, Manfredonia, Mattinata, Monte Sant'Angelo, Peschici, Rignano Garganico, San Giovanni Rotondo, San Marco in Lamis, Sannicandro Garganico,

Vico Del Gargano, and Vieste.

The total area of the study area is 150,857 hectares. There are two commercial ports, in Manfredonia and Rodi Garganico, and the closest airports are located in Foggia (104 km) and Bari (143 km). The rail network there is the least developed infrastructure network in the area, with a couple of regional operators providing short-length connections. There is a fairly good road network connecting small towns and cities, but bus transportation does not fully satisfy transportation needs due to its low frequency (Report on Mediterranean Adventure Tourism, 2020).

The Gargano area, with a population of 172,207 people as of 2019, is characterized by three key sectors: tourism, industrial activities, and agriculture. Tourism accounts for 11% of the national GDP, which is worth 900 million euros [40], while the agricultural sector plays a significant role in shaping land use patterns. However, some agricultural areas have experienced abandonment due to water scarcity, inadequate infrastructure, and insufficient services.

Most of the local population is employed in small-scale agricultural activities (7367 people), particularly related to olive tree and vegetable farming, and especially in the tourist industry (10,305 people). The area is heavily affected by the migration of the youngest generations to northern Italy and other countries, motivated by the search for better job opportunities [41].

The industry still has poor development, with low industrialization rates and most companies having a size less than the provincial average. The manufacturing industry contributes 7.5% to the provincial total, with only rare exceptions. The construction industry occupies a small percentage of the provincial GDP (4.40%). Specialized production, such as electrical machinery, electronic and optical equipment, motors, generators, and transformers, enjoys a certain vitality, with workers making up about 91% of the province's total for this category [41].

The Rodi Garganico Citrus Oasis is a natural area in the northern part of Gargano, known for its centuries-old production of citrus fruits, such as "Duretta del Gargano" and "Bionda del Gargano" oranges, as well as "Femminello" lemon, which received IGP acknowledgment [42].

2.2 Geospatial Analysis

Data on land cover, land use and transitions between different categories are some of the most frequently requested pieces of information for the formulation of sustainable land management and planning strategies, needed to provide information to support decision- making processes at community, national and local levels and to verify the effectiveness of environmental policies [43,44].

The ever-increasing availability of high-resolution geographic data provided by land government agencies, research infrastructures and environmental agencies is contributing significantly to the ability to study recent soil transformations at unprecedented scales of detail [45].

As a result, technical–scientific and dissemination initiatives are flourishing, including the periodic reports on land consumption produced by the Higher Institute for Environmental Protection and Research (ISPRA) and the Research Centre on Soil Consumption (CRCS), which provide a very detailed statistical picture of the transformations underway in Italy without, however, going into the merits of the territorial dynamics that triggered, favored, or counteracted them. In this study, therefore, we aim to contextualize the observations on changes in land use and cover in the study area, investigating the determining factors and discussing their possible implications.

The CORINE (Coordination of Information on the Environment) program is mainly based on the remote sensing technique, using classification techniques that depend on the automatic and semi-automatic interpretation of images.

In this context, for the analysis of transformations, of particular importance is the CORINE Land Cover (CLC) initiative, created at the European level specifically for the de- detection and monitoring of the characteristics of land cover and use, with particular attention to protection needs. The main aim of the initiative is to dynamically verify the state of the environment in the community area, to provide support for the development of common policies, monitor their effects, and propose possible corrective measures. Between 1985 and 1990, the European Commission promoted and financed the CORINE program and set up an information system on the state of the environment in Europe. Nomenclature systems and working methodologies for

the creation of the CORINE Land Cover (CLC) database have also been developed and approved at the European level. It was initially implemented in 1990, while subsequent updates refer to the years 2000, 2006, 2012, and 2018.

CLC products are based on the photointerpretation of satellite images following the standard methodology and nomenclature with the following characteristics:

- A total of 44 land cover classes at the third hierarchical level of the CORINE nomenclature;
- Minimum mapping unit (MMU) for the coverage of 25 hectares;
- Minimum amplitude of linear elements of 100 m;
- MMU for change (LCC) of 5 hectares.

For the analysis of the dynamics of agroforestry land uses, we adapted the methodology proposed in the Territorial Coordination Plan of the Province of Foggia [40]. Through the application of a land cover change classification matrix that simplifies the interpretation of possible changes between any two classes to a limited number of processes, we obtained the following:

- *Persistences*:
  - PU: artificial surfaces;
  - RA: arable soil;
  - PC: permanent crop;
  - PP: pastures;
  - PH: heterogeneous area;
  - PN: natural areas.
- *Agricultural Conversions*:
  - HE: arable to heterogeneous areas;
  - ER: permanent crop to arable areas;
  - AP: pasture to other agricultural use;
  - TC: other agricultural use to permanent crops;

- OC: heterogeneous areas to permanent crops;
- CP: other agricultural use to pastures.

- *Net Transformation*:

- UR: urbanization of natural or agricultural areas;
- DC: deforestation for cropping (e.g., from woods and shrubs to meadows and pastures);

  DP: deforestation for pastures (e.g., from woods and shrublands to complex particulate cropping systems);
- DU: de-urbanization and de-impermeabilization of soils;
- NA: recolonization by natural areas (processes of secondary recolonization by spontaneous vegetation, e.g., from arable land in non-irrigated areas to woods and shrubs).

Despite the consolidated validity of the CORINE system, a limitation of this methodology lies in the fact that the classification adopted by the CORINE program is unable to capture detailed ecosystem variations, especially in natural areas [46]. It is also important to consider that the CORINE Land Cover (CLC) dataset presents an MMU of 25 hectares for areal phenomena [47], thus preventing the detection of small territorial fragmentations with dimensions smaller than 25 hectares and with different classifications compared to surrounding surfaces that exceed this threshold. This problem takes on particular relevance in the territorial characteristics of the study area, mainly involving the lands classified as "2.2.1 Vineyards" and "2.2.2 Plantations of fruit trees and berries". Their extension, especially in coastal areas, often exceeds 25 hectares, highlighting the need for ancillary data for a more accurate estimate [48].

2.4 Assessment of Land Use Drivers

For the identification of the potential drivers of the observed LULCC in the area studied, we performed a literature analysis based on Science Direct and Scopus. We considered very recent papers (2017–2023) and selected 31 drivers that apply to the study area among those analyzed in

these papers [9,49–52]. Table 1 reports the selected drivers grouped as (i) physical and anthropogenic or (ii) socio-economic factors.

Table 1. Drivers of land use change drivers.

ID	Physical and Anthropogenic	ID	Socio-Economic
D1	Population growth rural	D17	Migration
D2	Population growth urban	D18	Labor shortage
D3	Agricultural intensification: modern	D19	Cultural Change in religious patterns
D4	Agricultural intensification: traditional	D20	Level of education
D5	Agricultural extensification	D21	Customary land tenure system
D6	Irrigation (dams, rivers)	D22	Economic rising living standard
D7	Improved crop varieties	D23	Financial capital of rural farmers (poverty)
D8	Mining	D24	Foreign agricultural medium-scale investments
D9	Bushfire	D25	International funding/development aid
D10	Livestock	D26	Credits by family, bank, government or NGO
D11	Road network	D27	Science and research
D12	Soil type and fertility	D28	Service offered by extension officers
D13	Topography	D29	Governmental laws
D14	Rainfall variability	D30	National agricultural programs
D15	Temperature variability	D31	Fertilizer subsidies
D16	Wind intensity		

Demographic aspects and agricultural practices are the main anthropogenic factors, while soil type, topography and atmospheric phenomena are among the physical ones. The social factors include migration, unemployment, and level of education. The availability of financial resources is mentioned as economic factors.

To assess their relevance as LULCC drivers and their impact for the sustainable development of the rural Gargano, we individually interviewed 11 experts by means of an ad hoc questionnaire. Table 2 reports the affiliation, scientific background, and research or activity field of the experts interviewed.

Table 2. Affiliation, scientific background, and research or activity field of the experts for interviews.

ID	Affiliation	Background	Field of Research or Activity
E1	Polytechnic University of Bari, Italy	Territorial, Urban and Environmental Planning	Territorial, Urban and Environmental Planning
E2	University of Foggia, Italy	Social and Political Philosophy	Cultural Heritage
E3	University of Ferrara, Italy	Geological Sciences	Stratigraphic Geology and Sedimentology
E4	Ministry of Education, Italy	Agricultural Science	Rural Development
E5	Gargano National Park, Italy	Communication Studies	Protected Areas Management
E6	Gargano National Park, Italy	Economics	Ecotourism, Destination Management
E7	University of Foggia, Italy	Economics	Water Management, Regional and Local Land Use planning'
E8	University of Foggia, Italy	Agricultural Science	Remote Sensing, Land Use Change and Natural Resources Management
E9	University of Foggia, Italy	Economics	Bioeconomy and Renewable Energy
E10	University of Foggia, Italy	Economics	Rural Development
E11	University of Foggia, Italy	Natural Science	Land Planning

The experts were chosen through a process involving the review of published papers, recommendations from fellow scientists, and consultations with local institutions, including the University of Foggia and the National Park of Gargano. An essential criterion was their affiliation with scientific institutions in Italy and their thorough understanding of the causal relationships between driving forces and LULCC in the region.

The questionnaire was based on the information obtained from the geospatial analysis and the literature review. It was formed of two core sections, reserved, respectively, in the assessment and by means of Likert scales, of (i) the land use changes and (ii) their drivers. The LULCCs were assessed with respect to their potential effects on the sustainable development of the case study area. To this end, the experts were asked to consider the LULCC that occurred in the period analyzed (2000–2018), using a geographical representation and a table reporting their extension in hectares and % in terms of the surface in the year 2000. Subsequently, the respondents were provided with a list of the LULCC, divided into three different categories according to the classification described in Section 2.2 (i.e., persistence, agricultural conversions and net transformations), and asked the following question:

Q1. What potential effects on the sustainable development of the Gargano region can be

anticipated as a result of the following LULCC which occurred between 2000 and 2018? (Possible answers: very negative; negative; slightly negative; none; slightly positive; positive; very positive).

It should be borne in mind that Q1 is not a simple question as it requires the respondents to perform an assessment of each single LULCC listed.

Subsequently, the respondents were asked to assess the LULCC drivers with respect to their ability to generate some land use changes in abstract (Q2) and their capability to produce specific LULCC (Q3):

Q2. To what extent have these factors contributed to causing one or more of the described 'changes' (persistences, agricultural conversions, or net transformations)? (Possible answers: not at all, they were a collateral cause of marginal importance, they were a relevant contributing factor, they were the main cause, they were almost the sole cause).

Q3. If the following factors have, in some way, contributed to causing the changes indicated in the columns, check the boxes in the corresponding intersections.

As with Q1, Q2 and Q3 are complex questions requiring a reiterated task to the respondent. Q2 has 31 responses (the number of the drivers identified), and Q3 has even a greater number as it requires the comparison of each driver with each LULLC reported from the analysis.

3.Results

3.1Geospatial Analysis

Table 3 summarizes the geospatial analysis whose results have been aggregated in three land cover macro-categories, namely, artificial surfaces, agricultural areas, and natural areas, with a breakdown of agricultural areas into three main sub-categories. The information reported relates to the extension of the categories' surface in the year 2000 (column a), the loss and the gain of the surface (respectively, columns b and c) in the period 2000–2018, the balance of that period (column d) and the new extension in 2018 (column e).

Table 3. Land use change in the period 2000–2018.

	2000 Extension	Loss (%)	Gain (%)	Balance (%)	2018 Extension
	a	***b***	***c***	***d = b − c***	***e = a + d***
Artificial Surfaces	4183.20	1100.71 (0.26)	2025.56 (0.48)	924.84 (0.22)	5108.04
Agricultural Areas	71,107.90	15,317.59 (0.21)	11,678.15 (0.16)	−3639.43 (−0.05)	67,468.46
Arable Soil	*31,625.69*	*2734.72 (0.08)*	*3175.48 (0.10)*	*440.76 (0.01)*	*32,066.45*
Permanent Crops	*22,064.49*	*1716.62 (0.07)*	*3307.86 (0.14)*	*1591.23 (0.07)*	*23,655.73*
Pastures	*2308.52*	*2198.82 (0.95)*	*385.94 (0.16)*	*−1812.87 (−0.78)*	*495.64*
Heterogeneous Areas	*15,109.20*	*8667.42 (0.57)*	*4808.85 (0.31)*	*−3858.56 (−0.25)*	*11,250.64*
Natural Areas	111,153.99	41,757.74 (0.37)	44,472.34 (0.4)	2714.59 (0.02)	113,868.59

The first result relates to the remarkable increase in the artificial surface, which, in 2018, was 22% more extended than in 2000, with a net gain of almost one thousand ha.

This is especially due to the expansion of urban areas, industrial facilities, port construction, extraction activity and the building of sport and leisure facilities. The loss of 26% of the surface is largely an internal conversion especially related to the transition from different kinds of urban areas and the transformation of some discontinuous urban areas in industrial sites or leisure facilities.

On the contrary, the agricultural areas lost about 3.6 thousand hectares passing from 71 to 67 and reducing by about 5%. This reduction is mainly due to a sharp decline in pastureland, which lost more than 78% of its original surface, and due to the downgrading of heterogenous areas. These two categories declined by more than 5.6 thousand hectares overall, especially in favour of natural areas. At the same time, there has been a significant increase in the areas with more intensive agricultural activity, such as that pertaining to arable soil and permanent crops, gaining more than 1.5 thousand ha.

Another relevant result concerns the extension of the natural areas with a net gain of 2%, corresponding to 2.700 hectares, which have been recolonized by spontaneous vegetation. A large part of the loss and gain for this macro category occurred between internal subcategories and can therefore be conceived as internal conversions. Most of the transformations that affected natural areas in the period 2000–2018 involved surfaces used for agricultural purposes (4.8 thousand ha). Of these, almost half, about 2.4 thousand ha, underwent a sort of hybridization, transitioning from natural areas to heterogeneous surfaces with the following CORINE Land Cover label: “Land principally occupied

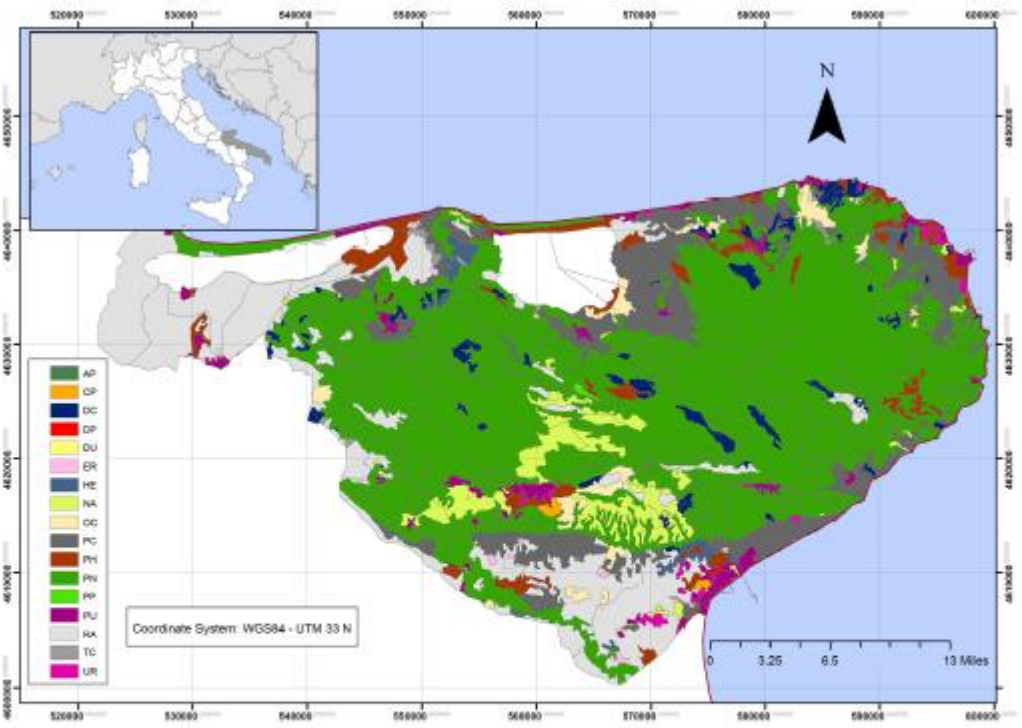
by agriculture, with significant areas of natural vegetation". Another thousand hectares were converted into arable land. On the other hand, during the same period, natural areas withdrew 7.6 thousand hectares from agricultural uses. This explains the net increase in natural areas.

These results are the effect of the transformation dynamics that occurred in the period 2000–2018 in terms of (i) persistences, (ii) agricultural conversions, and (iii) net transformations.

These dynamics are reported in Table 4 which accounts for the surfaces affected by each specific change category in the two reference years: the surface that, in 2018, was affected by the specific change is reported both in absolute terms (expressed in hectares) and in relative terms compared to the extension that, in 2000, was classified in that same category 1. A graphical representation of the data reported in Table 2 is provided by the map shown in Figure 1.

Table 4. Land use transformation in the period 2000–2018.

Cod.	Change Category	Macro Category	Surface (ha) in 2018	% of Surface in 2000
PU	Artificial Surfaces	Persistence	4064.70	97%
RA	Arable Soil	Persistence	28,890.96	91%
PC	Permanent Crops	Persistence	20,578.08	93%
PP	Pastures	Persistence	109.70	5%
PH	Heterogeneous Areas	Persistence	6881.67	46%
	Total Agricultural Areas	*Persistence*	*62,541.55*	*88%*
PN	Natural Areas	Persistence	106,188.86	96%
HE	Arable to Heterogeneous Areas	Agricultural Conversions	1492.60	5%
ER	Permanent Crop to Arable Areas	Agricultural Conversions	337.42	2%
AP	Pasture to Other Agricultural Use	Agricultural Conversions	262.36	11%
TC	Other Agricultural Use to Permanent Crops	Agricultural Conversions	536.18	1%
OC	Heterogeneous Areas to Permanent Crops	Agricultural Conversions	3140.65	21%
CP	Other Agricultural Use to Pastures	Agricultural Conversions	311.95	0%
UR	Urbanization of Natural or Agricultural Areas	Net Transformations	1043.35	1%
DC	Deforestation for Cropping	Net Transformations	4801.94	4%
DP	Deforestation for Pastures	Net Transformations	47.76	0%
DU	De-urbanization and De-impermeabilization of Soils	Net Transformations	118.51	3%
NA	Recolonization by Natural Areas	Net Transformations	7638.43	11%



Legend: *AP: Pasture to Other Agricultural Use; CP: Other Agricultural Use to Pastures; DC: Deforestation for Cropping; DP: Deforestation for Pastures; DU: De-urbanization and de-impermeabilization of Soils; ER: Permanent Crop to Arable Areas; HE: Arable to Heterogeneous Areas; NA: Recolonization by Natural Areas; OC: Heterogeneous Areas to Permanent Crops; PC: Permanent Crops; PH: Heterogeneous Areas; PN: Natural Areas; PP: Pastures; PU: Artificial Surfaces; RA: Arable Soil; TC: Other Agricultural Use to Permanent Crops; UR: Urbanization of Natural or Agricultural Areas*

Figure 1. Representation of land use transformation in the period 2000–2018.

Regarding the Persistences, the analysis reveals that, for the most part, the various land uses have been retained substantially to the same extent in the analyzed period. This is certainly true for the artificial surfaces (PU), which have a persistence of 97%. Figure 1 shows that the persistence of natural areas (PN) is undoubtedly the most significant in terms of absolute surface quantities, seeing that green, the color indicating the persistence of natural areas, is the dominant color in the map, representing more than 106 thousand ha. Arable soil and permanent crops have also remained quite stable. In contrast, the heterogeneous areas and especially the pastures have undergone a significant transformation, with a low or very low persistence of 46% and 5%, respectively.

Partly, this is due to the Agricultural Conversions: 262 hectares of pastures (about 11% of the land extension in 2000) have been converted to other agricultural uses. Heterogeneous areas have also changed, yielding a substantial 3 thousand hectares (21%) to permanent crops and receiving 1.5 thousand hectares from arable surfaces.

As for the Net Transformations, the most significant one involves the conversion of areas previously destined for other purposes that have been reclaimed by nature. This amounts to over 7.6 thousand hectares subtracted almost exclusively from agricultural uses, comprising 55% (4.2 thousand ha) from heterogeneous areas, 25% (1.9 thousand ha) from pastures, and 15%(1.17 thousand ha) from arable surfaces. The analysis of net transformations highlights another major change represented by deforestation for cropping. In 2000, there were 4.8 thousand hectares of forestland that became agricultural cultivations in 2018. Finally,the urbanization of natural or agricultural areas covers an area of more than 1000 hectares, the majority of which (approximately 90%) were previously used for agriculture.

3.2. Assessment of Land Use Drivers

The information collected from the experts is summarized in Tables 5 and 6. The former is dedicated to the analysis of the drivers' ability in generating the LULCC. The data reported derive from questions Q2 and Q3 described above. The possible responses to question Q2 were transformed into numbers using the following scoring: not at all = 0, they were a collateral cause of marginal importance = 1, they were a relevant contributing factor = 2, they were the main cause = 3, they were

almost the sole cause = 4. The “Degree of Causality” column in Table 5 reports, for each driver, the average of the scores it received from each respondent. As this variable is based on the question concerning the extent to which drivers contributed to the observed changes, this value can be regarded as a measure of the drivers’ propensity to generate one or more changes. The columns “# of Changes Caused” and “# of Experts Agreeing on Average” synthesize the responses to Q3. The first reports the number of different LULCCs caused by each driver according to the experts’ views and is a sort of measure of the effectiveness of the drivers; the second indicates, for each driver, the average number of experts who identified it as a possible cause of the affected LULCC and is a measure of the intensity, perceived by the experts, of the drivers’ action. The details of the information collected with Q3 are reported in Appendix A.

Among the physical and anthropogenic drivers, the one perceived as the most responsible (Degree of Causality 1.81) for producing LULCC is D13 Topography. It refers to the physical characteristics of the terrain and the morphology of the landscape, which, in the Gargano area, exhibit a significantly diversified territorial pattern with pronounced altimetric gradients, a distinctive mountainous coastline, and extensive forest cover. These elements are evidently perceived as particularly impactful on decisions regarding territorial organization by the interviewed experts. This driver has been identified as the cause of 13 LULCCs with a high level of agreement among the interviewed experts. Within this group of drivers, D5 Agricultural Extensification (expansion of cultivated areas with lower input intensity) also plays a prominent role, being perceived as potentially responsible for 16 LULCCs, although with a lower causality than D13 but with an even higher level of agreement among the experts. D3, which pertains to the modernization of agriculture, is also a significant driver, gathering the highest convergence among the interviewed experts (3.38) and influencing 13 changes.

Table 5. Causality of drivers of land use changes.

	Drivers	Degree of Causality	# of Changes Caused	# of Experts Agreeing on Average
Physical and Anthropogenic	D1 Population growth rural	0.18	10	1.4
	D2 Population growth urban	1.36	7	3.14
	D3 Agricultural intensification: modern	1.63	13	3.38
	D4 Agricultural intensification: traditional	1.18	15	2.2
	D5 Agricultural extensification	1.63	16	2.81
	D6 Irrigation (dams, rivers)	0.81	7	1.57
	D7 Improved crop varieties	1.36	9	3
	D8 Mining	0.27	3	1.33
	D9 Bushfire	1.72	11	1.9
	D10 Livestock	1.09	5	2.2
	D11 Road network	0.63	4	2.25
	D12 Soil type and fertility	1.54	8	2.25
	D13 Topography	1.81	13	2.23
	D14 Rainfall variability	1.27	13	1.69
	D15 Temperature variability	1.27	14	1.57
	D16 Wind intensity	0.54	5	1.2
Socio-economic	D17 Migration	1.81	12	3.41
	D18 Labor shortage	2.09	14	3
	D19 Cultural change in religious patterns	0.27	9	1.33
	D20 Level of education	1.36	11	1.63
	D21 Customary land tenure system	1.36	9	3
	D22 Economic rising living standard	1.72	11	2.18
	D23 Financial capital of rural farmers (poverty)	1.63	15	1.73
	D24 Foreign agricultural medium-scale investments	0.45	9	1.55
	D25 International funding/development aid	1.36	9	2.22
	D26 Credits by family, bank, government, or NGO	1.09	10	1.6
	D27 Science and research	1.18	9	1.88
	D28 Service offered by extension officers	1.09	6	2.5
	D29 Governmental laws	1.45	14	1.71
	D30 National agricultural programs	1.63	14	2.28
	D31 Fertilizer subsidies	1.63	8	3

Table 6. Land use change effects on local sustainable development.

Cod.	Change Category	Macro Category	Effect (sum)	Surface (ha) in 2018
PU	Artificial Surfaces	Persistence	1	4064.70
RA	Arable Soil	Persistence	10	28,890.96
PC	Permanent Crops	Persistence	10	20,578.08
PP	Pastures	Persistence	2	109.70
PH	Heterogeneous Areas	Persistence	−4	6881.67
PN	Natural Areas	Persistence	21	106,188.86
HE	Arable to Heterogeneous Areas	Agricultural Conversions	3	1492.60
ER	Permanent Crop to Arable Areas	Agricultural Conversions	−12	337.42
AP	Pasture to Other Agricultural Use	Agricultural Conversions	−11	262.36
TC	Other Agricultural Use to Permanent Crops	Agricultural Conversions	9	536.18
OC	Heterogeneous Areas to Permanent Crops	Agricultural Conversions	0	3140.65
CP	Other Agricultural Use to Pastures	Agricultural Conversions	11	311.95
UR	Urbanization of Natural or Agricultural Areas	Net Transformations	−20	1043.35
DC	Deforestation for Cropping	Net Transformations	−24	4801.94
DP	Deforestation for Pastures	Net Transformations	−11	47.76
DU	De-urbanization and De-impermeabilization of Soils	Net Transformations	15	118.51
NA	Recolonization by Natural Areas	Net Transformations	5	7638.43

Finally, in this category, a mention should also be made of D9 Bushfire, D12 Soil Type and fertility, D2 Population Growth Urban, and D7 Improved Crop Varieties as being among the major driving forces behind LULCC in Gargano.

Among the socio-economic drivers, there is the one exerting the highest degree of causality overall: D18 Labor Shortage, with an index of 2.09. It is perceived to be the potential cause of 14 changes by an average of three experts. Other indicative drivers associated with a negative socio-economic trend are among the major contributors to land use changes in the Gargano area. These include D17 Migration and D23 Poverty of Rural Farmers, evidently seen as obstacles to maintaining adequately remunerative agricultural activities.

Within the socio-economic factors, there are also drivers representative of the effects of agricultural policy, such as D30 National Agricultural Programs and D31 Fertilizer Subsidies which are conceived as potentially very effective in terms of land use change by the experts.

Table 6 is based on the information from Q1. For this question, the responses have been encoded into numbers as follows: Very negative = −3; Negative = −2; Slightly negative = −1; None = 0; Slightly positive = 1; Positive = 2; Very positive = 3. For each LULCC, the table reports the sum of the scores assigned by respondents. This method of aggregation facilitates the interpretation of results, as

conflicting connections with opposite signs will result in a decrease in the effect, while agreement reinforces the effect, producing an overall collective picture.

From this table, it emerges that Persistences are seen as substantially positive. PN Natural Areas, which also exhibit the maximum extension, shows the highest score. In other words, among the land cover categories, it is most strongly associated with the sustainable development of the area according to the experts' perception. This is consistent both with the concept of sustainability itself, which sees the conservation of resources, especially natural ones, as its main operation, and with the purpose of the area: since it is mostly covered by a National Park, it is institutionally a protected area. At the same time, the maintenance of agricultural areas, denoted by RA Arable Soil and PC Permanent Crops, is considered another essential element of the area's development path.

On the contrary, Net Transformations are generally perceived as negative in terms of sustainable development. DC Deforestation for Cropping, DC Deforestation for Cropping, and DP deforestation for Pastures are considered warning signs to monitor closely. An exception is DU De-urbanization and De-impermeabilization of Soils, which, with a score of 15, is considered a positive element from the perspective of sustainable development for the area.

Finally, from the analysis of Agricultural Conversions, a clear message emerges: heterogeneous areas and pastures are considered important indicators of the socio-economic and ecological balance of the territory. Their reduction in favor of other agricultural arrangements (ER Permanent Crop to Arable Areas and AP Pasture to Other Agricultural Use) is seen as a potential threat, as evidenced by the strongly negative scores they accumulate.

Conversely, their expansion (HE Arable to Heterogeneous Areas and CP Other Agricultural Use to Pastures) is viewed favourably in the context of sustainable development.

4. Discussion

The Table A1 (Appendix A) cross-references the drivers with the LULCC, allowing for the identification of the drivers that may have a greater influence on the sustainable development of the territory. These are, in particular, the factors causing the most impactful changes according to the

experts' views. As explained, among these changes, there are DC: Deforestation for Cropping and UR: Urbanization of Natural or Agricultural Areas. Concerning the former, the experts identified D3 Agricultural Intensification: Modern and D7 Improved Crop Varieties with an agreement of the 63% and 45%, respectively, as possible causes.

Other relevant drivers for this change potentially harmful to sustainable development, each identified by 27% of experts, are D21 Customary Land Tenure System, D26 Credits by Family, Bank, Government or NGO, D29 Governmental Laws, and D31 Fertilizer Subsidies. At the same time, UR: Urbanization of Natural or Agricultural Areas is influenced by D2 Population Growth Urban (72%) and D22 Economic Rising Living Standard.

On the other hand, D13 Topography, D17 Migration, D18 Labor Shortage, and D20 Level of Education, identified by 36%, 54%, 36%, and 36% of experts, respectively, are considered factors influencing the persistence of PN Natural Areas. D17, D18, along with D5 Agricultural extensification, are important drivers also for another sensitive change, DU De-urbanization and De-impermeabilization of Soils.

Given the above, we debate the potential implications that these land use changes may have on fragile ecological balances of the territory and community livelihoods. As for the former, ecological risks take the form of soil erosion, dry lands, water shortage [53]

and biodiversity loss [54]. These imbalances would, in turn, affect the benefits provided by ecosystem services on nearby communities [55–57]. As for the latter, land use changes would alter food and livelihood production and security [58,59] and make smallholder farmers more vulnerable to climate variability or income sources so as to alter the original agricultural production into modern and 'touristic-oriented' farmhouses [60].

Nonetheless, these latter transformations ultimately attract new job opportunities [61],reshape social inclusiveness and social innovation in rural and peri-urban areas [62,63],emphasize existing cultural traditions [64,65], reduce outbound youth migration [65,66],strengthen cooperation among farmers and capitalize on local competitive advantages [67,68].

Therefore, land transformations, as a result of human activity, could also have severe impacts on the supply of land and generate conflicts in the local community spanning from private interests and

income generation to conservation and restoration goals [69,70], thus resulting in diverse land configurations of the territory. Also, agricultural intensification and expansion over time has led to degraded ecosystems, thus affecting soil depletion, overexploitation and loss of the resilience of agro-systems [71]. Identifying the underlying drivers of the above dynamics is crucial for determining the actions to be taken to guide the LULCC process along desirable development trajectories.

In this regard, the present work provides an insightful framework, enabling the distinction of drivers that require attention depending on whether the goal is to (i) control the most concerning LULCC or (ii) promote those that are more desirable.

Factors such as agricultural intensification and other agricultural support policies are among the first group, as they are perceived as potential sources of pressure on the natural component of the territory. On the other hand, these drivers (e.g., improved crop varieties, services provided by extension officers, national agricultural programs, fertilizer subsidies) counteract abandonment, which is promoted by the customary land tenure system and its land ownership fragmentation effects. These drivers play, therefore, a crucial role in the balanced development of the territory.

In the second group, there are drivers like topography, which makes certain areas inaccessible and remain naturally untouched, and other factors such as the level of education and the agricultural extensification process.

Some policy implications that favour a more desirable land cover directly stem from these facts:

■ Supporting agriculture through targeted measures and actions conditioned by compliance with environmental constraints;

■ Addressing the fragmentation of land ownership with initiatives aimed at promoting or rewarding the concentration of agricultural lands;

■ Supporting agricultural extensification by providing forms of diversification and income support for farmers;

■ Promoting environmental awareness aimed at developing an understanding of the natural environment and the local archaeological, naturalistic, historical, and cultural heritage value.

In addition, to combat agricultural abandonment and the loss of important ecosystem services, such as food production or soil fertility, the promotion of ad hoc ‘proximity agriculture’and 0-km products

and cuisine would reduce market asymmetries and sustain small farmers in the long run to ensure the economic viability of local agricultural production [72].

Further policy measures such as offering payments to farmers' initiatives (such as crop rotations, biodegradable soil covers) for the preservation of land and natural resources would help promote sustainable practices of the local agriculture.

The Regional Authority [73] has recently welcomed the latest European Union 'Farm to Fork' strategy, which rewards farmers for promoting adequate sustainable practices, creating further opportunities for the ecological transition of agri-businesses that are beneficial to local communities. [74,75].

Another value added of the present study is the reproducibility of the employed methodology to similar areas—e.g., other Mediterranean or EU countries—such that the insights deriving from this study can be beneficial in other contexts, other than providing homogeneity of comparisons across regions.

Some limitations of this study are the limited number of experts interviewed; the potential errors occurred in the GIS analysis, especially in areas prone to difficult identification, such as heterogenous or borderline areas; the use of a questionnaire to collect the information, as this facilitated quick data collection, on one hand, but limited the depth of explanations on the other; and the effort required of respondents hindered the collection of additional but relevant information, such as a specific quantification of the causal relationship between drivers and changes.

The next steps include the following: to increase the number of experts to bring additional perspectives; to broaden the temporal analysis by incorporating additional data points along the timeline to achieve a more precise trend assessment; to extend the analysis to quantify the drivers, as many of them can be operationally defined as variables using the latest data from the most recent census; to advance beyond expert perception and establish quantitative causal relationships; to conduct a comparative analysis of the perceptions of different stakeholders to capture diverse viewpoints on the LULCCs that have occurred and on future trends; and to extend the survey to include the perception toward LULCC of the farmer population of the area to quantitatively assess the causal relation between drivers and LULCC.

5.**Conclusions**

This study delved into the understanding of crucial aspects of land use and land cover change by identifying the major transformations that occurred in the area of Gargano in the period 2000–2018 and exploring the influential factors that played a pivotal role in driving these transformations. This work represents a preliminary analysis of the Gargano region's evolving land use as a foundational step in its exploration.

The analysis revealed that the area has experienced micro-changes, with a predominant portion characterized by persistences. These persistences, particularly in natural areas and agricultural activities, are perceived positively, signifying their potential contribution to the area's future sustainable development. More precisely, natural areas have, in general,experienced an increase in the overall surface, despite relinquishing nearly 5 thousand hectares to agriculture and another thousand to urbanization in the period analyzed, as they reclaimed, in the same period, more than 7.5 thousand hectares. It is worth highlighting the importance experts gave to pastures and heterogeneous areas which emerged as significant indicators of the socio-economic and ecological equilibrium of the area: their variations are considered relevant with reductions viewed as potentially detrimental and increases perceived as advantageous in terms of sustainable development.

At the same time, urbanization and deforestation emerged as focal points of major concern, reflecting the heightened sensitivity surrounding these transformative processes.

Finally, with an eye to the broader field of rural land use change, the understanding of micro-transformations that occurred in the Gargano area, addressed in the present study, help the decision-making authority to reduce long-term asymmetries in view of adopting ad hoc strategies for land use changes and meeting the green transition more rapidly in the immediate future.

Appendix A

Table A1. Causality of drivers of land use changes—no. (%) of experts (n = 11) who mentioned the driver (in row) as a possible cause of the change (in column).

		Persistences						Agricultural Conversions					Net Transformations				
	Drivers	***PU***	***RA***	***PC***	***PP***	***PH***	***PN***	***HE***	***ER***	***AP***	***TC***	***OC***	***CP***	***UR***	***DC***	***DP***	***DU***	***NA***
Physical and Anthropogenic	D1	0 (0)	1 (0.09)	2 (0.18)	2 (0.18)	0 (0)	1 (0.09)	0 (0)	1 (0.09)	1 (0.09)	0 (0)	2 (0.18)	0 (0)	1 (0.09)	2 (0.18)	0 (0)	1 (0.09)	0 (0)
	D2	7 (0.63)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.09)	2 (0.18)	0 (0)	0 (0)	2 (0.18)	1 (0.09)	0 (0)	8 (0.72)	1 (0.09)	0 (0)	0 (0)	0 (0)
	D3	0 (0)	6 (0.54)	5 (0.45)	0 (0)	0 (0)	1 (0.09)	1 (0.09)	5 (0.45)	5 (0.45)	4 (0.36)	5 (0.45)	1 (0.09)	0 (0)	7 (0.63)	1 (0.09)	1 (0.09)	2 (0.18)
	D4	0 (0)	5 (0.45)	3 (0.27)	1 (0.09)	2 (0.18)	2 (0.18)	2 (0.18)	2 (0.18)	2 (0.18)	3 (0.27)	3 (0.27)	2 (0.18)	0 (0)	2 (0.18)	2 (0.18)	1 (0.09)	1 (0.09)
	D5	0 (0)	5 (0.45)	5 (0.45)	2 (0.18)	1 (0.09)	1 (0.09)	4 (0.36)	3 (0.27)	2 (0.18)	2 (0.18)	4 (0.36)	4 (0.36)	1 (0.09)	3 (0.27)	2 (0.18)	3 (0.27)	3 (0.27)
	D6	0 (0)	3 (0.27)	1 (0.09)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.18)	1 (0.09)	1 (0.09)	0 (0)	0 (0)	0 (0)	2 (0.18)	0 (0)	1 (0.09)	0 (0)
	D7	0 (0)	6 (0.54)	2 (0.18)	0 (0)	1 (0.09)	0 (0)	0 (0)	5 (0.45)	3 (0.27)	2 (0.18)	2 (0.18)	0 (0)	0 (0)	5 (0.45)	0 (0)	1 (0.09)	0 (0)
	D8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.18)	1 (0.09)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.09)	0 (0)
	D9	1 (0.09)	2 (0.18)	0 (0)	2 (0.18)	1 (0.09)	1 (0.09)	0 (0)	0 (0)	1 (0.09)	0 (0)	1 (0.09)	2 (0.18)	2 (0.18)	3 (0.27)	0 (0)	0 (0)	5 (0.45)
	D10	0 (0)	0 (0)	2 (0.18)	4 (0.36)	0 (0)	1 (0.09)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.18)	0 (0)	0 (0)	2 (0.18)	0 (0)	0 (0)
	D11	5 (0.45)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.09)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.18)	0 (0)	0 (0)	1 (0.09)	0 (0)
	D12	0 (0)	4 (0.36)	2 (0.18)	0 (0)	0 (0)	1 (0.09)	0 (0)	3 (0.27)	2 (0.18)	0 (0)	1 (0.09)	1 (0.09)	0 (0)	4 (0.36)	0 (0)	0 (0)	0 (0)
	D13	0 (0)	1 (0.09)	1 (0.09)	2 (0.18)	1 (0.09)	4 (0.36)	3 (0.27)	1 (0.09)	0 (0)	2 (0.18)	2 (0.18)	4 (0.36)	0 (0)	0 (0)	1 (0.09)	2 (0.18)	5 (0.45)
	D14	0 (0)	2 (0.18)	1 (0.09)	0 (0)	1 (0.09)	1 (0.09)	3 (0.27)	1 (0.09)	2 (0.18)	1 (0.09)	2 (0.18)	2 (0.18)	0 (0)	2 (0.18)	0 (0)	2 (0.18)	2 (0.18)
	D15	0 (0)	2 (0.18)	1 (0.09)	0 (0)	1 (0.09)	1 (0.09)	3 (0.27)	1 (0.09)	2 (0.18)	1 (0.09)	2 (0.18)	2 (0.18)	0 (0)	1 (0.09)	1 (0.09)	2 (0.18)	2 (0.18)
	D16	0 (0)	0 (0)	1 (0.09)	0 (0)	1 (0.09)	0 (0)	2 (0.18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.09)	0 (0)	1 (0.09)
Socio-economic	D17	1 (0.09)	0 (0)	0 (0)	3 (0.27)	4 (0.36)	6 (0.54)	6 (0.54)	0 (0)	1 (0.09)	1 (0.09)	1 (0.09)	6 (0.54)	2 (0.18)	0 (0)	0 (0)	5 (0.45)	5 (0.45)
	D18	0 (0)	1 (0.09)	1 (0.09)	5 (0.45)	6 (0.54)	4 (0.36)	6 (0.54)	0 (0)	1 (0.09)	1 (0.09)	1 (0.09)	5 (0.45)	1 (0.09)	0 (0)	1 (0.09)	3 (0.27)	6 (0.54)
	D19	1 (0.09)	0 (0)	0 (0)	0 (0)	1 (0.09)	1 (0.09)	3 (0.27)	0 (0)	0 (0)	1 (0.09)	1 (0.09)	1 (0.09)	0 (0)	0 (0)	1 (0.09)	0 (0)	2 (0.18)
	D20	1 (0.09)	0 (0)	1 (0.09)	0 (0)	0 (0)	4 (0.36)	2 (0.18)	0 (0)	0 (0)	1 (0.09)	2 (0.18)	2 (0.18)	1 (0.09)	2 (0.18)	0 (0)	1 (0.09)	1 (0.09)
	D21	0 (0)	3 (0.27)	0 (0)	4 (0.36)	4 (0.36)	0 (0)	2 (0.18)	2 (0.18)	0 (0)	2 (0.18)	0 (0)	3 (0.27)	0 (0)	3 (0.27)	0 (0)	0 (0)	4 (0.36)
	D22	6 (0.54)	2 (0.18)	0 (0)	0 (0)	0 (0)	1 (0.09)	0 (0)	3 (0.27)	1 (0.09)	2 (0.18)	0 (0)	0 (0)	5 (0.45)	1 (0.09)	1 (0.09)	1 (0.09)	1 (0.09)
	D23	1 (0.09)	1 (0.09)	1 (0.09)	3 (0.27)	1 (0.09)	1 (0.09)	3 (0.27)	1 (0.09)	1 (0.09)	1 (0.09)	0 (0)	6 (0.54)	0 (0)	1 (0.09)	1 (0.09)	2 (0.18)	2 (0.18)
	D24	0 (0)	2 (0.18)	2 (0.18)	0 (0)	0 (0)	0 (0)	1 (0.09)	1 (0.09)	1 (0.09)	3 (0.27)	0 (0)	0 (0)	0 (0)	2 (0.18)	1 (0.09)	1 (0.09)	0 (0)
	D25	0 (0)	2 (0.18)	3 (0.27)	0 (0)	0 (0)	0 (0)	0 (0)	4 (0.36)	1 (0.09)	4 (0.36)	2 (0.18)	0 (0)	0 (0)	2 (0.18)	1 (0.09)	1 (0.09)	0 (0)
	D26	0 (0)	0 (0)	1 (0.09)	0 (0)	0 (0)	3 (0.27)	0 (0)	1 (0.09)	1 (0.09)	3 (0.27)	1 (0.09)	1 (0.09)	0 (0)	3 (0.27)	1 (0.09)	1 (0.09)	0 (0)
	D27	0 (0)	3 (0.27)	3 (0.27)	0 (0)	0 (0)	1 (0.09)	0 (0)	3 (0.27)	1 (0.09)	2 (0.18)	2 (0.18)	0 (0)	0 (0)	1 (0.09)	0 (0)	1 (0.09)	0 (0)
	D28	0 (0)	3 (0.27)	4 (0.36)	0 (0)	0 (0)	0 (0)	0 (0)	3 (0.27)	1 (0.09)	3 (0.27)	1 (0.09)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	D29	0 (0)	2 (0.18)	1 (0.09)	1 (0.09)	1 (0.09)	3 (0.27)	0 (0)	2 (0.18)	1 (0.09)	3 (0.27)	1 (0.09)	3 (0.27)	1 (0.09)	3 (0.27)	1 (0.09)	0 (0)	1 (0.09)
	D30	0 (0)	4 (0.36)	5 (0.45)	1 (0.09)	1 (0.09)	0 (0)	1 (0.09)	3 (0.27)	1 (0.09)	5 (0.45)	3 (0.27)	1 (0.09)	1 (0.09)	4 (0.36)	1 (0.09)	0 (0)	1 (0.09)
	D31	0 (0)	7 (0.63)	3 (0.27)	0 (0)	0 (0)	0 (0)	0 (0)	5 (0.45)	1 (0.09)	3 (0.27)	1 (0.09)	0 (0)	0 (0)	3 (0.27)	1 (0.09)	0 (0)	0 (0)

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Chapter 4

The UNESCO global geopark model for sustainable development in marginalised areas: Investigating perceptions and social acceptance in a sub-regional context

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Abstract

We examine the potential of the UNESCO Global Geopark (UGGP) model in the Gargano area of Apulia region, Italy, by addressing two questions: 1) How are UGGP elements perceived by local stakeholders as drivers for sustainable development? 2) What actions can enhance its social acceptance in the region? Using a combined SWOT-SOr analysis and Fuzzy Cognitive Mapping, UGGP-related variables are viewed as less effective compared to more tangible development efforts. However, entrepreneurship and local knowledge show potential to enhance local development and complement UGGP elements. Strategic interventions are needed to increase awareness and integrate UGGP policies into broader development strategies.

Keywords: UNESCO Global Geopark; Social acceptance; SWOT-SOr; Fuzzy cognitive mapping; Sustainable development

1. Introduction

Tailored, region specific solutions, can make a tangible positive change towards sustainable regional development in peripheral, marginalised rural areas. Particularly this is important in areas which are distinguished by significant biological, cultural, and geological diversity. To ensure positive impact and success, these initiatives should be grounded in the needs, perspectives, and visions of local stakeholders (Love and Powe, 2020; Li et al., 2019). The collaborative design of a development project can enhance stakeholders' self-awareness, facilitate the creation of a unified vision within the community, and increase the capability (Abreu et al., 2024) to propose innovative ideas and value-adding initiatives, ultimately benefiting the region as a whole (LEADER, 2023). Bottom-up approach to development strategies is important as this strengthens the internal capacities of the communities, increasing their resilience potential (Li et al., 2019).

The significance of natural resources in enhancing community resilience to climate change and economic recessions has been well documented (Dogru et al., 2019; Fischer, 2018; Clarke et al., 2018; Miaoyin et al., 2024). Investments in natural resources and their appropriate management significantly bolster community resilience (International Panel on Climate Change - IPCC, 2022).

However, nature-protected areas often face limitations in integrating conservation goals with local development needs (Worboyset et al., 2015; Brockington et al., 2012; Anaya and Espírito-Santo, 2018; Brockington and Wilkie, 2015; Oldekop et al., 2016). In some cases, the creation of protected areas is considered as an example of 'green-grabbing' with the enclosure of land or sea for environmental purposes (Fairhead et al., 2012; Scoones et al., 2013; Benjaminsen and Bryceson, 2012; Holmes, 2014; Bluwstein et al., 2018), depriving the rights of local communities. However, in recent years conservation projects like UNESCO Geopark are embedding local communities and their interests (UNESCO, 2024)

In the last decade, the concept of UNESCO Geoparks has emerged as a compelling model that integrates geological heritage conservation with community well-being and environmental stewardship. It offers a complex strategy for fostering sustainable local development integrating the preservation of geological heritage with educational programmes, participatory research, social projects, and green economic activities (Henriques and Brilha, 2017; Rodrigues et al., 2021; Ferreira

and Valdati, 2023). UNESCO Geopark is not only about geological heritage, but rather about a complex and dynamic ecosystem, which is a habitat also for biological species, harbour of cultural and historical heritage. The main aim of UNESCO Geopark is to harmonise the protection of geological, natural, and cultural heritages with sustainable local community development. The UNESCO Geopark is a promising model for regions wishing to balance the twofold objectives of preservation of natural landscapes and sustainable economic development and livelihoods. This approach offers new opportunities and benefits, in particular to marginalised, lagging behind regions. In an extremely globalising world, the territory-based approach promoted by the UNESCO Global Geopark (UGGP) to development is important as it promotes and revitalises local resources, revives local knowledge, and protects local identity, preserving the authenticity of these marginalised areas.

Due to its collaborative design and customisation to local context, the UGGP approach is an appealing model for marginalised regions. It promotes inclusive economic development, which is based on valorisation of local assets. Rather than enforcing external development strategies, the UGGP model emphasises the territory's assets and potential (Zouros, 2004). Geoparks transform marginalised areas into dynamic centres of innovation, ecological awareness, and national pride by accentuating the unique qualities and untapped potential of these areas (UNESCO, 2024).

As such, a bottom-up approach is a primary requirement for the establishment of UNESCO Geopark and community involvement in all stages of its operation as set forward by the UNESCO (Komac, 2015; Halim, 2011; Pásková, 2018; Halim and Ishak, 2017; Sánchez et al., 2021; UNESCO Global Geoparks, 2024).

In this paper we have tackled this issue with respect to a specific territory which can benefit from the UGGP implementation, the geographic area of Gargano, located in Apulia Region (South Italy). Two research questions are addressed: RQ1) to what extent the elements of the UGGP model are perceived by local stakeholders as possible drivers for local sustainable development; RQ2) what actions can be implemented to foster the social acceptance of the UGGP model as a framework for the area's sustainable development by the local stakeholders. To investigate these questions, we applied a combined approach based on a SWOT-SOr experiment with local stakeholders and Fuzzy Cognitive Maps to analyse their perceptions.

The remainder of the paper is organised as follows: section two provides the theoretical base for the analysis linking the concept of Socio-ecological system (SES) to the role of the UGGP in boosting sustainable development. Section three describes the applied methodology, including data collection methods and the development of the SWOT SOr and FCMs approaches. The results are presented in section four and are discussed in section 5, which also provides concluding remarks and suggestions for future research.

2. Theoretical Framework

Sustainable development is a ubiquitous topic in contemporary scholarship. Economists underscore the efficiency and stability of financial systems and institutions to achieve sustainability (Malizia et al., 2020; Skica et al., 2020), social scientists point out social cohesion and equality (Sommer, 2019), while environmentalists emphasise the critical necessity for environmental initiatives and ecosystem balance (Cao et al., 2021).

Visioning development through sustainability lenses requires the ability to think about the scale of a system, its components, and their interactions (Ukaga et al., 2010; Langston et al., 2019; Barron et al., 2023). In this regard, the development strategies require a complex and holistic approach. Recognising the interconnectedness of the system-building components will help to design policies and development strategies that foster resilience, reduce vulnerability, and ensure long-term sustainability in both human and ecological dimensions.

In this vein, UNESCO Geopark is a model which recognises the interconnectedness of environmental and human dimensions of regional development. It is a promising model for regions wishing to balance the twofold objectives of preservation of natural landscapes and sustainable economic development and livelihoods. As described by UNESCO, UGGPs are distinct, unified geographic regions that encompass sites and landscapes of international geological importance, managed through an integrated approach focused on protection, education, and sustainable development (UNESCO, 2024).

This requires a comprehensive and multistage process to establish a Geoparks under the UGGP umbrella, which is based on both a scientifically proven demonstration of the international value of

the local geological sites and a bottom-up strategy design. This means to involve all the relevant local and regional stakeholders and authorities (e.g. land owners, community groups, tourism providers, indigenous people, and local organisations). A strong local multiple partnership with long-term public and political support is crucial to reach a comprehensive strategy that will meet prioritised community main development goals, while showcasing and protecting the area's geological heritage. Prior to being granted UNESCO Geopark designation, a site must demonstrate the scientific significance of its geological legacy (international value) and have well-established management and community development initiatives. This process often takes several years.

The success and long-term sustainability of Geoparks is dependent on more than just the ecological and economic benefits that they produce, but also predominantly on the support of local people. The enduring impact of UNESCO Geoparks mostly relies on local support (Komac, 2015; Halim, 2017; Pásková, 2018; Halim and Ishak, 2017; Sánchez et al., 2021). UNESCO geoparks demonstrated to be a powerful catalyst for the growth of the communities around them (Brilha, 2018; McKeever and Zouros, 2005; Farsani, 2011; Lee and Jayakumar, 2021). According to a survey of 25 geoparks, about 80% of the respondents agreed that geoparks promote local products (Farsani et al., 2012), whereas other studies indicated infrastructure improvement, and increase in the number of new local businesses, or services (Lee and Jayakumar, 2021). An online survey of 103 UGGPs in 2019 illustrates the positive influence of UGGPs on local economies (UNESCO, 2024). Similarly, Lee and Jayakumar (2021) assessed a qualitative work among UGGPs, according to which respondents indicated that sustainable tourism in and around geoparks (98%), driving local economic development (85%), attracting tourists or making tourism more attractive (96%), facilitating engagement with local and indigenous communities (93%), improving participation of women in economic activities (71%), and raising and attracting additional funding and support for geoparks (83%) had impacted on the development of the investigated areas due to the establishment of potential UGGPs.

Although there is reported a strong positive economic impact, little research is available which provides a quantitative analysis to support the scope of the impact.

Drawing on scientific and grey literature, we constructed a UGGP local development model by delineating its primary elements and their interactions.

First, as highlighted by Martínez-Martín et al. (2023), the UGGP framework serves as a model for territorial development and outdoor education through geo-tourism and geosciences (Martínez-Martín et al., 2023). Moreover, Rosado-González et al. (2023) describe UGGP as a participatory sustainable development framework. Catana & Brilha (2020) mention geo-education programmes and activities of the UGGP framework as a tool for sustainability. Van Geert (2019) argues that the UGGP model is a new form of territorial marketing; whereas Pérez-Romero et al (2023) and De Castro et al. (2022) stress the UGGP model as a development strategy, which unites various municipalities and builds networks between various actors and stakeholders.

By encouraging green economic activities, like sustainable tourism (e.g. declined under geological, agricultural, cultural, spiritual), Geopark helps marginalised communities leveraging their unique resources for economic and social revival (Brilha, 2018) and building constructive networks (Panzer-Krause, 2018). As such, it creates employment opportunities and encourages the growth of small local businesses, thus diversifying and stimulating local economies and making them resilient against external economic shocks (Farsani et al., 2014). Geo-brands created within Geoparks strengthen area visibility, boosting destination marketing strategies, and consequently increasing the sense of belonging, ownership, connection, and local pride. This improves social cohesion within the community. In many geoparks, communities that initiated geotourism, organic farming, and eco-friendly products, reduced reliance on unsustainable industries (extractive, mass tourism). Research on European geoparks reveals that these initiatives lead to increased employment and income for the local population, all while protecting their environment (Zouros, 2004).

These features define the quality criteria for geopark candidates and the main areas they should focus on (UNESCO). From this stream of literature, the main UGGP elements are identified. They can be classified into social and ecological variables, whereas the quality criteria outline their interaction. Figure 1 depicts the emerging model.

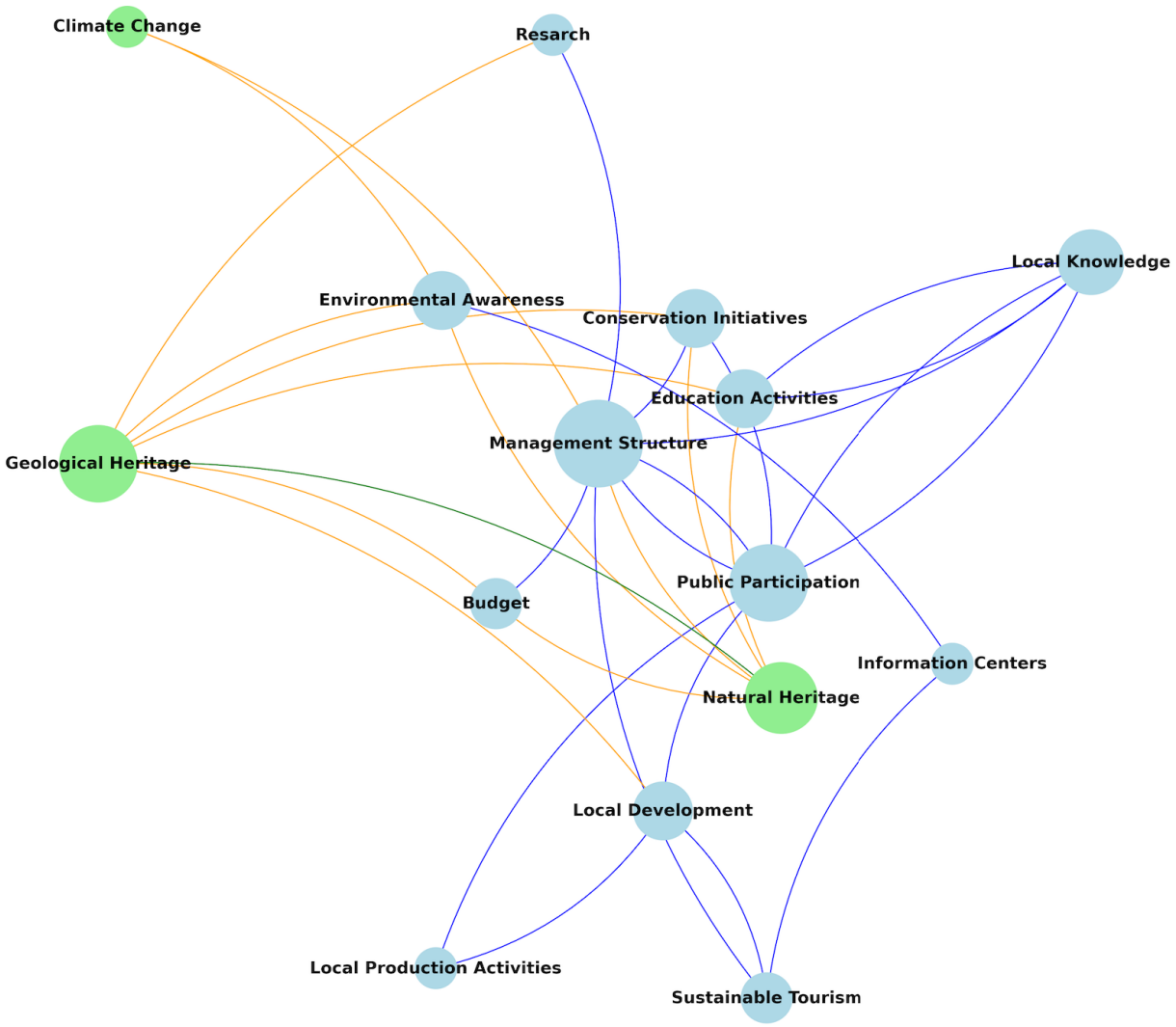

Figure 1. The Unesco Global Geopark Model. *Source*: Author's own elaborations.

In Figure 1, green nodes represent ecological variables. These are associated with the natural environment, such as *Natural Heritage* and *Geological Heritage*. Social nodes are depicted in light

blue colours. These variables are characterised by human activities, such as *Public Participation, Management Structures and Education.* Green links indicate interactions between ecological variables. For example, a connection between *Geological Heritage* and *Natural Heritage.* Blue links indicate social to social interactions. For instance, a connection between *Public Participation and Management Structure.* Social-to-ecological interactions are represented by orange links. For instance, an illustration of a relationship between *Education Activities and Geological Heritage.* Finally, no ecological-to-social interactions are present in Figure 1.

The SES theory (Ostrom et al., 1994; Berkes and Folke, 1994, 2008; Ostrom 2009) is a way to frame ecological and social components in a rational way. SES approach considers human societies and ecosystems as interdependent, which have constant influence on each other, producing a dynamic loop of feedback (Ross et al., 2024). The SES approach considers human and ecological systems together as a complex phenomenon that constantly changes not only under the impact of internal, but also external factors. It underscores the need to balance the well-being of ecological systems with the well-being of social systems, which enhances the overall resilience, adaptability, and sustainability of SES (Berkes et al., 2008).

There are three main components of SES: ecological system dynamics, socio-economic dimension, and feedback loops. Ecological system dynamics include natural resources, biodiversity, and ecosystem services. The socio-economic dimension encompasses local communities, governance structures, economic activities, and cultural practices and values. Feedback loops are reciprocal interactions between human and ecological systems. One example of a feedback loop can be a transition from intensive agricultural practices to sustainable land use, which positively impacts the state of natural resources, biodiversity, and overall ecosystem services, which in turn brings a positive impact on human well-being.

SES is self-organised, although there is a certain role for hierarchical decision-making structures. Polycentric governance approach allows for flexibility and adaptability enabling SES to respond effectively to various challenges as well as opportunities. SES is dynamic and thus requires an adaptive management that allows for learning and adjustments over time (Ostrom, 2009). Changes within SES often have a cyclical character, therefore adaptive management based on ecological and

social feedback is crucial (Gunderson, 2002; Holling, 2002). The system's future is frequently uncertain because of the non-linear nature of its fundamental causal interactions. The factors influencing performance are both rapidly and slowly changing (Rocha et al., 2019). Over time local communities, especially those keeping traditional lifestyles and practices develop certain adaptive mechanisms, which make them resistant against unpredictable changes and help them to maintain ecosystem services (Folke and Berkes, 1994, 2000). Often social innovations born within the communities bring transformative changes to SES resulting in system-wide shifts in behaviour and governance (Westley, 2013; Suitner et al., 2022). In summary, SES main characteristics include complexity, dynamism, self-organisation, adaptability and uncertainty.

For these reasons analysing UGGP requires appropriate methodological approaches suitable to deal with such complexity.

3. Materials and methods

The analysis presented in this paper has been carried out in relation to a concrete territory which can benefit from the UGGP implementation, namely the geographic area of Gargano, located in Apulia Region (South Italy).

To investigate our research questions, we employed a combined approach directed at grasping the knowledge of local stakeholders and at analysing it with quantitative methods. The first objective is to understand if the UGGP model's elements are perceived by local stakeholders as possible development drivers. We designed an experiment to collect stakeholders' views on how the UGGP variables interact with contextual elements in the development process. To this end we enriched the UGGP model (section 2) with other variables, brought from previous analysis of Gargano, to attain a tailored picture of the area easily recognizable by local stakeholders.

To collect the information, we performed a SWOT-SOr experiment with the relevant stakeholders (Weihrich, 1982; Gellynck and Vermeire, 2010). The information gathered has then been treated using the Fuzzy logic underlying the Fuzzy Cognitive Maps (FCMs) a method capable of dealing with the emergencies and non-linearity typical of a complex SES. FCMs have been applied with two ends: i) to reach a ranking of sustainable drivers according to the stakeholders' vision and ultimately

understand the role of UGGP variables as development drivers according to their grading (RQ1); ii) to perform a scenario analysis to predict which development pattern better exploits UGGP elements to define the guiding line for a socially acceptable sustainable strategy for UGGP implementation (RQ2).

The underlying idea behind this methodological choice lies in the fact that local communities have a better understanding and knowledge about the social-ecological system they belong to as they deal with their environments on a daily basis, than other stakeholders which are external to the investigated territory (Berkes et al., 2008; Fabricius and Koch, 2004).

In this section we explain: i) the SWOT SOr experiment, specifying how we reached the final list of variables of the system depicting the area (section 3.1), and how we classified these variables to fit the SWOT structure; ii) the basics of the FCMs method applied for the FCM analysis (section 3.2).

3.1 The SWOT-SOr experiment

To grasp and exploit stakeholders' knowledge to the purpose of our analysis, we first employed a SWOT-SOr (Strengths, Weaknesses, Opportunities, Threats and Strategic Orientation) approach with the declared goal to understand which strengths and weaknesses are most relevant for the sustainable development of the Gargano in the medium term (5 years), based on the perception of various stakeholders, but implicitly gathering (their latent) information on the perception about a UGGP project.

To this end, we transformed the UGGP model (depicted in figure 1) in a SWOT matrix, adding several contextual variables. This step was based on previous studies on the area dealing both with social and physical (and land-use and land use change) contexts of Gargano (Esengulova et al., 2023, 2024).

In particular, Author 2023 identified a couple of social variables complementing the UGGP model, such as: a) *the presence of community action groups* that have a consolidated experience (more than 30 years) of driving development projects at local level, as well as environmental conservation initiatives, and cultural and tourism programs, all interlinked aspects related with the UGGP focus; b) *a poor entrepreneurship mindset*: Private initiative, with agro-food firms firstly, in the area are the

most marginalised categories in terms of stakeholders empowerment and this reflects the limited support and initiatives from local entrepreneurs to development processes

Authors (Esengulova et al., 2024) pointed out the relevance of LULC on geodiversity and biodiversity, which are key components of geoparks (Turner et al., 2021; Datta, 2022). As a result, key elements of Gargano SES were identified. In particular, we extended the UGGP model with four more variables: a) *availability of extended natural areas*, b) *land abandonment*, c) *deforestation* and d) *outmigration*.

Building on these early findings and the UGGP model, a comprehensive list of variables was set, which encapsulates the core socio-ecological dynamics of the Gargano area, serving as a framework for the subsequent analysis. To fit these variables into the SWOT model, we determined whether these variables should be considered internal (easily controllable, as internal resources of weaknesses) or external (uncontrollable as external trends, resources or shocks) to a potential local partnership tasked with designing a development strategy for the area under analysis in the medium term. Secondly, based on the conditions of the local context, we also determined whether the variables classified as internal could be conceived as strengths or weaknesses, and those classified as external as opportunities or threats. The complete list of variables, with their explanation and classification is provided in the appendix (Table A1).

In order to collect the stakeholders' vision on the fundamental interplay between the system variables, we provided a group of respondents with a SWOT matrix which allowed them to reflect on the interaction of the strengths (and weaknesses) with the opportunities and threats. The respondents have been identified through a prior stakeholder analysis included in Esengulova et al., 2023 which was useful to identify the most influential categories of actors, in particular hospitality sector, universities, agricultural and craft associations, local authorities (municipalities and national park, consortia and regional development organizations, environmental NGOs, agricultural cooperatives, local businesses.

To ensure the consistency of the responses and the robustness of the whole picture, we set a square matrix with 5 elements for each category (S,W,O,T) and respondents have been kindly requested to carefully answer these questions:

1) *Do the strengths listed help seizing opportunities and mitigating threats to development?*

2) *Do the weaknesses hinder the exploitation of opportunities and/or exacerbate threats?*

For each possible interaction, respondents were also asked to assess the impact of S and W on O and T by attaching a weight between 0 (no impact) to 3 (maximum impact).

We kept the amount of the weights in each row to a maximum of 12 (Gellynck and Vermeire, 2010) so that the sizes of the weights would be the same for all respondents This mechanism allowed stakeholders to rethink their first review and possibly change the combination of the weights. The sum of the rows and columns provides a first idea of how the strengths or weaknesses affect opportunities and threats. The strategic orientation is then shown by the amount of the weights in each quadrant. The strategic orientation is given by the quadrant reaching the top-value sum as follows (Gellynck and Vermeire, 2010):

First Quadrant (SO): *we have good Ss to grasp Os: Attack!*

Second Quadrant (ST): *our Ss enable us to fight Ts: Defend!*

Third Quadrant (WO): *we have too many Ws to grasp Os: Change!*

Fourth Quadrant (WT): *we have too many Ws to grasp Os: Clean Ws facing the Ts: Face the crisis!*

Finally, respondents were also asked to assess the impact of other possible interactions, that is between strengths and weaknesses and, as such, between opportunities and threats, and the impact that each variable could have on the sustainable local development. This served as a preparatory phase for the Fuzzy analysis.

3.2 Fuzzy cognitive mapping

The interaction between variables were then used as a computational model to further analyze the system by applying fuzzy inference. This method allowed us to respond to two further questions: a) where the system goes, if things remain at their status-quo; b) what-if some external influence occurs. The former analysis is suitable to grasp a general idea of the relative importance of the variables; the latter is suitable to investigate our RQs as it allows us to find the best development drivers and compare various strategies in the FCM scenarios' analysis.

The analysis is founded on the search of the system equilibrium - i.e. steady state - that is a state where the values of the system variables do not change (i.e. remain stable over time). To this purpose iterative computation is performed. In an initialization phase all variables are set at their initial state represented by a value equal to 1. In the iteration phase, the new state is computed as a function of its previous state and that of other variables which are connected with it, as shown in the following eq. [1].

$$v_{i,t} = f\left(v_{i,t-1} + \sum_{j=1}^{n-1} \quad v_{j,t-1} w_{j,i}\right) [1]$$

where $v_{i,t}$ is the value of variable *i* at time *t*, $v_{i,t-1}$ and $v_{j,t-1}$ are, respectively, the values assumed by variables *i* and *j* at the time *t-1*, and $w_{j,i}$ is the impact of variable *j* on variable *i*, and function *f* is a monotonic increasing transformation. As in Ozesmi and Ozesmi (2004), we used the simple logistic function $1/(1 + e^{-1x})$ which has the advantage of transforming the variables value in the range [0,1]. Eq. [1] is performed until the system reaches a steady state.

The steady state of a variable can be interpreted as the importance of that variable within the system as perceived by the respondents. Thus, the comparison of the steady states allows obtaining the internal evolution path of the system, that is, where the system converges without external intervention. The what-if analysis can be then performed, maintaining at their maximum the values of certain variables (those representing the development drivers) during the simulations. Then, the obtained value given by the difference between the new variables' state and their steady state, can be interpreted as the effect of the perceived intervention.

4. Results

This section is organized into three subsections to provide a structured presentation of the findings. Sub-section 4.1 analyses the stakeholders' capability of recognizing UGGP concepts, including a preliminary analysis to assess whether stakeholders can adequately associate specific variables with the concept of UGGP; sub-section 4.2 presents the SWOT-SOr experiment, devoted to capture

essential system information to inform the subsequent FCM analysis; and sub-section 4.3 which, through policy scenario simulations based on FCMs, investigates the two research questions.

4.1 Stakeholders' capability of recognizing UGGP concepts

A connection of some specific variables with the UGGP model is already made in the description of the specific variables. In order to verify if this connection is adequately recognized by stakeholders, an online questionnaire was conducted with 20 respondents selected on the basis of a previous partnership analysis (Authors, 2023) including agricultural and economic associations and public institutions (Table 1). Their task was to rate how strongly they believe each variable in the model is connected to the concept of an UGGP, using a Likert scale from 1 (=Not at all connected) to 5 (=Strongly connected)[1].

Table 1: Categories of stakeholders that participated in the preliminary perception questionnaire

Categories of Stakeholders	Number of Participants
Resort (Hospitality)	2
University	4
Craft and Artisans Associations	2
Local Authorities (Municipalities and National Parks)	5
Consortia and Regional Development Organizations	3
Environmental NGOs	2
Agricultural Cooperatives	1
Local Businesses	1
Total	n=20

Source: Authors' own elaborations.

[1] All subjects have provided appropriate informed consent.

The results are reported in Table 2 which displays the means for the centered score of each variable[2]. In particular three variables, namely Conservation (S1), Governance (01) and Geology (O4), were found to be significantly greater from the mean ($p < 0.01$ using a t-test for a single sample), indicating that they are definitely recognized as UGGP related concepts by the respondents. As such, we can expect this connection when stakeholders proceed with the SWOT-SOr evaluation.

Table 2. Perceived connection with UGGP's model

Code	Variable	Mean	
S1	Conservation	0.51	*
S2	Education	0.26	
S3	Activities	-0.39	
S4	Action	-0.24	
S5	Knowledge	0.11	
W1	Participation	-0.29	
W2	Entrepreneurship	-0.44	
W3	Awareness	0.26	
W4	Information	-0.14	
W5	Sustainable Tourism	0.31	
O1	Governance	0.41	*
O2	Funds	0.21	

[2] The scores on each variable were first centered by subtracting from the individual scores the individual's mean score over all 20 variable's values. This is because individual differences in variances of value ratings are usually meaningful. The subsequent normalization process, would 'eliminate' these real differences in the extent to which individuals rate the variables (Saris, 1988).

O3	Nature	0.31	
O4	Geology	0.36	*
O5	Research	0.31	
T1	Abandonment	-0.29	
T2	Deforestation	-0.04	
T3	Outmigration	-0.84	
T4	Inaccessibility	-0.34	
T5	Climate Change	-0.04	

Notes: *statistically significant ($p<0.01$) one-sample t-test; n = 20.

In the remainder of the analysis, we use these three variables to test if UGGP model is socially acceptable as a tool to implement a sustainable development strategy and refer to them as 'UGGP-related variables'.

4.2 The SWOT-SOr experiment

The SWOT-SOr experiment was performed with the aim to evaluate interactions between key variables and their strategic positioning. A group of ten people (Table 3), representing stakeholders from the hospitality and education sector, economic associations, and public institutions, independently assessed relationships between internal and external variables to derive strategic insights for sustainable development[3].

[3] All subjects have provided appropriate informed consent.

Table 3. Categories of stakeholders that participated in the SWOT-Sor experiment

Category	Role/Organization	Number of participants
Hospitality - Resort	Tourism services/hospitality	2
Academic	Research and development	2
Trade Association	Support for artisans and small businesses	2
Public Authority	Municipal administration	1
Public Authority	Environmental protection and park management	2
Public Authority	Water resource management and land reclamation	1
Total		n=10

Source: Authors' own elaborations.

Stakeholders employed a structured matrix to examine variable interactions, and their responses were consolidated (summed-up) into a comprehensive SWOT-SOr matrix (Table A2). The data were then normalised in the range [0,3] (Weihrich, 1982; Freedman and Philips, 2000). The aggregation procedure facilitated a comprehensive evaluation of strategic orientations, allowing for the discovery of the quadrant with the highest values and its implications.

The highest-scoring quadrant (33), Quadrant I (SO), emphasises an *attack!* strategy focused on leveraging internal strengths such as conservation initiatives, education, and local knowledge to grasp external opportunities like governance frameworks, funding availability, and geological heritage.

This suggests that stakeholders prioritise utilisation or synergies of these strategic directions. The opposite side (Quadrant III, WO), which totalized the second biggest score (31), a complementary strategic orientation focussing on mitigating vulnerabilities like limited participation and scarce information centers, was found. This latter also hindered opportunities for exploitation.

The main purpose of this methodological step, however, lies in the collection of the information on the interaction between the variables. As the SWOT-SOr experiment limited the analysis to some specific interaction - i.e. S and W on O and T - we asked the respondents to carry out an additional task to explore all possible interactions among variables, including sustainable local development. We then adjusted the signs of the values to take into account this aspect, summed up and normalized in the range [-3, 3] to obtain a squared matrix 21x21 (Kosko, 1986; Kok, 2009). This served as the basis for the next stage of FCMs analysis (Table A3).

4.3 Fuzzy cognitive mapping

We used the obtained FCM to first investigate where the system would go if things remain as they are - i.e. without any intervention. To this end, we replaced eq. [1] with the data retrieved from the squared matrix and reiterated the computation to reach the steady-state. The steady-state results provided the ranking of the variables according to their relative importance perceived by the stakeholders (table 4). Funds (O2), Conservation (S1), Governance (O1), Research (O5) and Presence of Community Action Groups (S4) exhibit the highest steady-state values, highlighting their importance in the system. We can argue that the availability of necessary financial resources along with good governance, well-preserved natural capital, and strong research capacities are critical for ensuring the region's long-term sustainability.

Table 4. Steady state estimates

Cod.	Variables	Steady State
S1	Conservation[#]	0.99
S2	Education	0.67

S3	Activities	0.16
S4	Action	0.95
S5	Knowledge	0.43
W1	Participation	0.12
W2	Entrepreneurship	0.50
W3	Awareness	0.22
W4	Information	0.12
W5	Sustainable Tourism	0.05
O1	Governance[#]	0.97
O2	Funds	0.99
O3	Nature	0.97
O4	Geology[#]	0.87
O5	Research	0.96
T1	Abandonment	0.26
T2	Deforestation	0.22
T3	Outmigration	0.01
T4	Inaccessibility	0.18
T5	Climate Change	0.02
OBJ	Sustainable Local Development	0.96
Min		0.01
Max		0.99
Mean		0.51
St.dv		0.39

Notes: [#] UGGP related variables. *Source*: Authors' own computations.

Geological heritage (O4) and Education (S2), while found less influential, play a supporting role in the system according to the stakeholders' perception. Geological heritage, with its connection to

regional identity and resources along with Education, which fosters skill-building, has an indirect yet vital role in facilitating long-term transformations in the community.

Entrepreneurship (W2) and Knowledge (S5), also exhibit a moderate importance. Their relatively low values indicate a necessity for further enhancement in these areas to facilitate sustained growth. Participation (W1), Awareness (W3), Information(W4), and Sustainable Tourism (W5) are all below the mean of 0.5, indicating their little perceived relevance. This suggests that these areas require more focused initiatives to increase participation of local population, enhance awareness, and develop sustainable tourism practices.

Several variables exhibited low values. Namely, Outmigration (T3) and Climate Change (T5) present the lowest steady-state values. This suggests that these elements, by being external factors and out of direct control of local communities, have less role in driving the system.

To answer RQ1, we simulated different scenarios to test which variables were most strongly perceived as drivers of development by local stakeholders, and whether those related to the concept of UGGP are among them. The initial hypothesis is that variables directly related to the UGGP model can be perceived as less effective drivers for local development, since the UGGP model is rooted in geo-conservation, education and sustainable tourism. As a result, stakeholders may prioritise other variables such as funding, governance or local actions groups.

Each variable that, according to the FCMs model, has an impact on others (out-link) was simulated as a policy, maintaining its maximum value throughout the simulation. Those variables presenting a negative definition - i.e. weaknesses and threats - the policy simulation should be intended as an intervention directed at reverting its operation or effect[4]. This led to a change in the steady state of the SLD variable. In Table 5 the variables have been ordered according to their impact on SLD from the highest to the lowest.

[4] For instance, a policy based on W2, *Low Entrepreneurship mindset*, should be conceived as an intervention or a set of interventions directed at enhancing the Entrepreneurship mindset.

Table 5. Impact of simulated policies on SLD (steady state)

Cod.	Variables	ΔSLD s.s.	
S3	Activities	0.0342184	*
W2	Entrepreneurship	0.0219112	*
W5	Sustainable Tourism	0.0053144	
S2	Education	0.0030106	
S5	Knowledge	0.0028485	
S4	Action	0.0025855	
W3	Awareness	0.0023540	
W4	Information	0.0021201	
T3	Outmigration	0.0011182	
W1	Participation	0.0008017	**
O2	Funds	0.0006948	**
O4	Geology[#]	0.0006872	**
T1	Abandonment	0.0006074	**
T2	Deforestation	0.0002034	**
O1	Governance[#]	0.0001778	**
O3	Nature	0.0001490	**
O5	Research	0.0001331	**
S1	Conservation[#]	0.0000606	**

Notes: [#] UGGP related variables; *exceeds the upper limit of the 99% bootstrap CI; **falls below the lower limit of the 99% bootstrap CI; 99% bootstrap CI: [0.0008924805, 0.01089435]. *Source*: Authors' own computations.

Using a bootstrap procedure, we also tested which variables have a significantly different impact on the SLD compared to the mean. As expected, all three variables strongly linked with the UGGP model (S1, O1, O4) fall below the lower limit of the 99% confidence interval (CI) constructed with the bootstrap, indicating that they were perceived as less impactful or not effective drivers of

development compared to others. It is worth noting that S1 (conservation initiative) is even ranked the lowest impactful among the possible interventions.

Although these variables have theoretical importance within the UNESCO Geopark model, their perceived efficacy in advancing sustainable development was significantly less than predicted. These findings indicate that there is a divergence between the theoretical potential of the UGGP model and its practical implication, eventually highlighting a lack of social acceptance on its adoption as a sustainable development strategy. While the UGGP model emphasises geoconservation, education and sustainable tourism, local stakeholders prioritise immediate, tangible interventions directly supporting the economic activities provided that S3 and W3 are the sole variables which exceeded the upper limit of the 99% bootstrap CI. This signals potential lack of support from the local community towards development strategies solely focused on the UGGP model. To provide visual support to the analysis, Figure 2 represents the effectiveness of SLD's drivers using a bar chart.

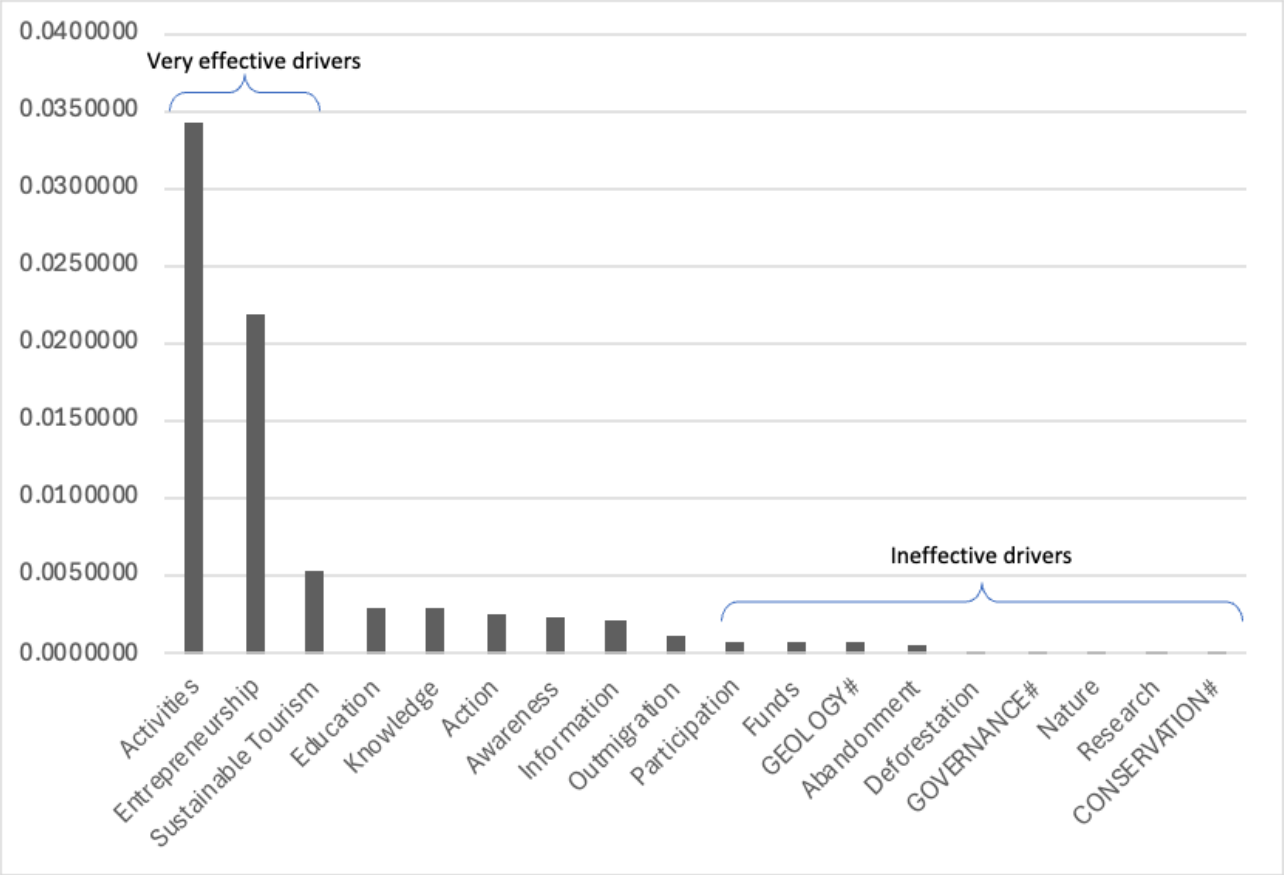

Figure 2. Effectiveness of SLD's drivers. *Source*: Author's own elaborations.

As shown, the UGGP-related variables fall within the ineffective group. This confirms the relevance of our RQ2 that focuses on the search of those interventions capable of fostering the social acceptance of 'UGGP-related variables' as possible drivers for the area's sustainable development.

To do this, we performed additional simulation to study the impact of each potential policy (out-link variables) on the SLD along with 'UGGP-related variables'. Table 6 reports the steady-state variation that these four targets caused to each driver. Figure 3 complements the analysis with a visual inspection.

Table 6. Steady-State percentage change for UGGP variables and SLD

Cod.	Drivers	SLD		Conservation		Governance		Geology	
S3	Activities	0.70	*	0.43	*	0.05	*	0.03	
W2	Entrepreneurship	0.45	*	0.40		0.07	*	0.08	*
W5	Sustainable Tourism	0.11		0.06		0.00		0.00	
S2	Education	0.06		0.26		0.03		0.05	*
S5	Knowledge	0.06		0.79	*	0.05	*	0.09	*
S4	Action	0.05		0.09		0.01		0.00	
W3	Awareness	0.05		0.61	*	0.02		0.04	
W4	Information	0.04		0.26		0.03		0.03	
T3	Outmigration	0.02		0.01		0.00		0.00	
W1	Participation	0.02		0.18		0.01		0.03	
O2	Funds	0.01		0.02		0.00		0.00	
T1	Abandonment	0.01		0.19		0.00		0.02	
T2	Deforestation	0.00		0.48		0.00		0.03	
O3	Nature	0.00		0.00		0.00		0.00	
O5	Research	0.00		0.07		0.00		0.00	
	Min	0.00		0.00		0.00		0.00	
	Max	0.71		0.79		0.07		0.09	
	Mean	0.11		0.26		0.02		0.03	
	25th percentile	0.06		0.42		0.03		0.04	

Notes: *exceeds the upper limit of the 99% bootstrap CI. 99% bootstrap CI: SLD [0.02 - 0.26]; Conservation [0.12 - 0.42]; Governance [0.01 - 0.03]; Geology [0.01 - 0.05]. *Source*: Authors' own computations

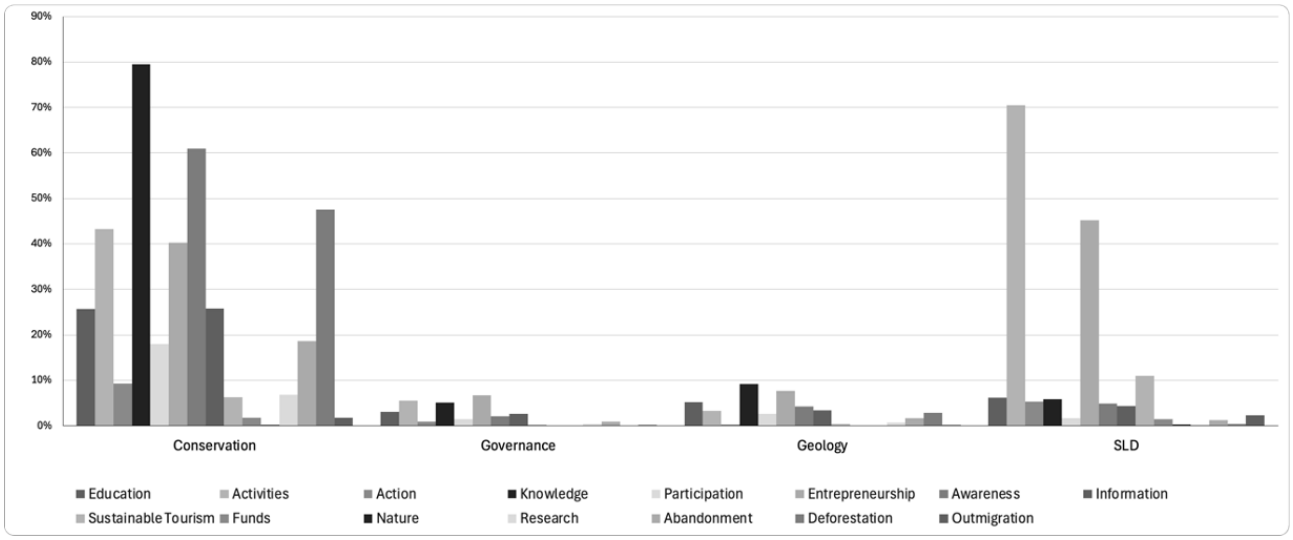

Figure 3. Steady-State Changes for UGGP Variables and SLD. *Source*: Authors' own elaborations.

We identified the most effective drivers per each target (i.e. those exceeding the upper limit of 99% bootstrap CI). The aim was to detect overlapping drivers capable of effectively enhancing both the SLD and 'UGGP-related variables'. We found no drivers capable of doing this for all the four variables at the same time. However, some overlap occurred between SLD and 'UGGP-related variables' taken two at a time. For instance, *Local Production Activities* (S3) is the best driver for SLD and one of the most effective for both *Conservation* and *Governance*. The second best SLD's driver, namely *Entrepreneurship* (W2), is also effective for both *Governance* and *Geology*. Figure 4 maps the whole overlapping potential of the effective drivers.

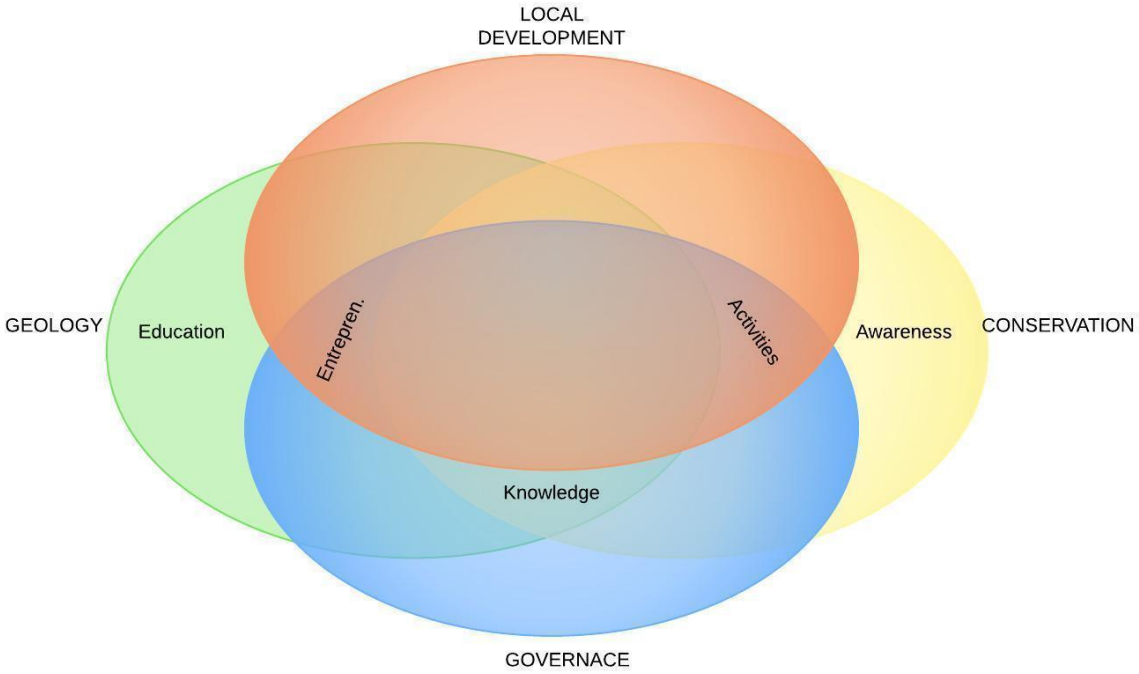

Figure 4. Overlapping of UGGP and SLD drivers. *Source:* Authors' own elaborations

It is a helpful tool to identify the drivers capable of 'hitting two targets with one arrow' - i.e., achieve SLD and increase the acceptability of the UGGP - as a starting point for the design of a socially acceptable development strategy founded on the UGGP model.

5. Discussion and conclusions

This study provides valuable insights into the perception and effectiveness of UGGP-related variables in driving sustainable local development. By employing a mixed-method approach, involving diverse stakeholders and experts, and utilizing Fuzzy Cognitive Mapping (FCM) to model complex interactions, we have shed light on the challenges and opportunities of integrating UGGP policies into broader development strategies.

Our main findings reveal that 'UGGP-related variables' are not perceived as effective development drivers, as stakeholders better focus on more tangible interventions related to the local economy

through well-established development agencies. This preliminary finding reveals a noteworthy perception among stakeholders that 'UGGP related variables' are seen as less effective drivers of sustainable local development. This perception underscores several implications, including raising awareness of the UGGP model's potential benefits, strengthening stakeholders' active involvement, and raising awareness and communication about the value of geological heritage and considering strategic interventions to address the untapped potential of UGGP policies.

At the same time, some drivers, such as *Entrepreneurship* and *Activities,* can both enhance local development and UGGP elements. Others - i.e. *Local Knowledge* - overlap solely among 'UGGP-related variables'. There are also drivers capable of fostering a specific element of the UGGP model, such as *Education* for the geological heritage and Awareness for conservation initiatives. None of these specific drivers for 'UGGP-related variables' should become the primary focus of the development strategy, as this can result in a lack of local support eventually leading to a policy failure. On the contrary, these specific drivers should be used to complement a core strategy founded on well accepted drivers. This would commence a virtuous pattern of community self-improvement capable of both reaching the tangible desired outcomes along with the increase of the UGGP acceptability, unlocking synergies among drivers themselves. For instance, initiatives mobilizing local knowledge can easily become a resource for local economic activities and entrepreneurship.

Despite a large mobilization of stakeholders, only few accepted to be interviewed. This potentially leads to the underrepresentation of some categories of stakeholders representing the main limitation of this study. Future research should consider expanding the number of respondents and to balance the categories' representation in order to provide some validation to these findings.

To build on these findings, further research should focus on exploring synergies between local development drivers performing further FCMs simulation. But a major research avenue is examining how the perception of UGGP policies evolves over time in response to awareness campaigns, stakeholder involvement, and successful interventions, while assessing the effects of combining UGGP-specific drivers with well-established development drivers on policy success and community commitment. Developing and testing indicators to measure the effectiveness of UGGP-related interventions in raising policy acceptability and achieving tangible development outcomes would also

be highly beneficial. Such indicators could be compared across different regions or contexts to better understand the variability of UGGP impacts and identify scalable solutions.

In conclusion, this study highlights the untapped potential of UGGP policies as complementary tools within broader development frameworks. By addressing data limitations, enhancing stakeholder diversity, and pursuing targeted future research, the alignment of UGGP initiatives with local economic goals can unlock meaningful progress in sustainable development while fostering greater acceptance and support among stakeholders.

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APPENDIX

Table A1 - Variables

Cod.	Name	Abbreviation	Description	Source	Type
S1	*Conservation initiatives*	*Conservation*	Conservation efforts are essential for protecting the landscape, managing local natural resources and Geological heritage holistically. Local partnerships and institutions are already engaged in various conservation initiatives, establishing a strong foundation for sustainable development. By prioritizing these efforts, they can preserve ecosystems and biodiversity, maintain landscape integrity, and foster sustainable resource use, ultimately enhancing environmental health and community well-being	UGGP Model	Internal/ Strength
S2	*Education activities*	*Education*	Education is a powerful tool for empowering communities and fostering engagement. Local partnerships and institutions have established educational structures, such as public schools and community programs. By leveraging these resources to deliver targeted educational programs, they can raise awareness of sustainable practices, environmental conservation, and cultural heritage, ultimately enhancing community involvement in rural development initiatives	UGGP Model	Internal/ Strength
S3	*Local Production Activities*	*Activities*	Local production activities, including traditional crafts and typical agricultural products, represent a rich production tradition that serves as a significant strength for rural development. By supporting and promoting these local production practices, partnerships can strengthen community identity and foster sustainable economic growth, ultimately contributing to enhancing the resilience of rural areas	UGGP Model	Internal/ Strength
S4	*Presence of Community action groups*	*Action*	Community action groups have a long tradition of driving local development projects, environmental conservation initiatives, and cultural and tourism programs. By fostering system thinking, these groups enhance their ability to navigate the complexities of local challenges and find effective solutions through a better understanding of the interactions and interdependencies among various elements in the community	Partnership analysis	Internal/ Strength
S5	*Local Knowledge*	*Knowledge*	By promoting local knowledge embedded in local traditions, cultural events, arts, farming practices and lifestyle, partnerships can strengthen community bonds and ultimately enhance sustainable development. This is related with local cultural heritage	UGGP Model	Internal/ Strength
W1	*Weak public participation in decision making*	*Participation*	Limited level of cooperation and engagement of the community hinders local partnerships' ability to implement effective development initiatives, reducing the overall impact of their efforts	UGGP Model	Internal/ Weakness
W2	*Low Entrepreneurship mindset*	*Entrepreneurship*	Limited support to and initiative from local entrepreneurs can restrict economic growth and innovation, creating challenges for local partnerships in fostering sustainable businesses and job opportunities	Partnership analysis	Internal/ Weakness
W3	*Low Environmental Awareness*	*Awareness*	Insufficient understanding of environmental issues among community members hampers efforts to promote sustainable practices, threatening the preservation of local ecosystems	UGGP Model	Internal/ Weakness
W4	*Scarce presence of information centres*	*Information*	The absence of effective information centers or resources results in a lack of access to essential data and knowledge, limiting community awareness and participation in rural development initiatives	UGGP Model	Internal/ Weakness
W5	*Few Sustainable Tourism Initiatives*	*Sustainable Tourism*	Mass, seasonal, and seaside tourism, along with limited sustainable initiatives, restrict the potential for sustainable development	UGGP Model	Internal/ Weakness

O1	*Governance and Participatory Frameworks*	*Governance*	Models like UNESCO Global Geoparks (UGGPs) promote governance structures that increase public participation in regional development. This helps local partnerships and formal institutions to involve local communities in decision-making processes and the management of local resources in a more sustainable way.	UGGP Model	External/ Opportunity
O2	*Rural Development Funds*	*Funds*	The availability of various funding sources, including the European Agricultural Fund for Rural Development (EAFRD), the LEADER program, and the European Regional Development Fund (ERDF), presents a significant opportunity for local partnerships. These funds can enhance community engagement, drive sustainable development, and foster collaborative initiatives in rural areas.	UGGP Model	External/ Opportunity
O3	*Availability of Natural Areas*	*Nature*	The biggest part of the Gargano area (approximately 114 thousand hectares) consists of natural areas, most of which are part of the National Park of Gargano. This area has experienced a 2% increase, equivalent to 2.7 thousand hectares recolonized by spontaneous vegetation in 2000-2018. This increase presents a significant opportunity for local partnerships to promote sustainable rural development by capitalising on the region's expanding natural resources and promoting biodiversity.	Land use analysis/UGGP Model	External/ Opportunity
O4	*Geological Heritage*	*Geology*	The geology of Gargano is characterised by diverse rock formations, unique landforms, and significant fossil sites. Leveraging this rich geological diversity presents a valuable opportunity for local partnerships to support sustainable development initiatives, educational programs, and eco-friendly infrastructure that highlight the region's geological authenticity.	UGGP Model	External/ Opportunity
O5	*Research*	*Research*	Local partnerships benefit from the presence of strong research institutes nearby, focusing on both technological and socio-economic aspects. This collaboration enhances the effectiveness of rural development initiatives, supports evidence-based decision-making, and drives sustainaBy strengthening their links with these institutes, partnerships can leverage valuable insights and innovative solutions tailored to local needs. This collaboration enhances the effectiveness of rural development initiatives, supports evidence-based decision-making, and drives sustainable practices	UGGP Model	External/ Opportunity
T1	*Land abandonment trend*	*Abandonment*	A steady trend of land abandonment has been recorded in the Gargano region, totaling 7.6 thousand hectares in rural areas from 2000 to 2018. This trend complicates efforts for local partnerships striving to revitalise these areas, as it reduces agricultural productivity, jeopardise traditional farming methods, and results in erosion of local knowledge, thereby leading to a decline in community engagement	Land use analysis	External/ Treat
T2	*Deforestation for cropping trend*	*Deforestation*	Deforestation for agricultural expansion threatens local ecosystems and biodiversity in Gargano, undermining environmental sustainability. Recent analysis shows that, despite the expansion of natural areas (with 2.7 thousand hectares recolonized by spontaneous vegetation) and an ongoing trend of land abandonment (with 7.6 thousand hectares abandoned from agriculture), significant deforestation has occurred, with 4.8 thousand hectares of forestland converted to agricultural cultivation by 2018. This trend poses challenges for partnerships focused on balancing agricultural needs with conservation efforts and is considered a warning sign for sustainable development, as it is generally perceived negatively in terms of ecological equilibrium	Land use analysis	External/ Treat
T3	*Outmigration trend*	*Outmigration*	The local outmigration rate of younger generation seeking better job opportunities in the Northern Italy and other countries is higher than the regional average. This demographic shift results in a decline in the local workforce and a loss of cultural heritage, posing significant	Land use analysis	External/ Treat

			challenges for local partnerships that rely on community involvement and engagement to drive rural development initiatives		
T4	*Inaccessibility*	*Inaccessibility*	The morphology of the landscape in the Gargano area features a significantly diversified territorial pattern characterised by pronounced altimetric gradients, a distinctive mountainous coastline, and extensive forest cover. This topography makes certain areas inaccessible, leaving them naturally untouched and contributing to land use changes in Gargano. These natural features pose challenges for local partnerships, as steep slopes and rocky terrain hinder accessibility and productivity, complicating the effective implementation of development initiatives	Land use analysis	External/ Treat
T5	*Climate change*	*Climate Change*	Gargano is characterized by semi-arid zones already prone to desertification, making these areas a fragile system. Under increased or unpredictable disturbances, they may experience significant alterations in species numbers and composition. This is critical for the current resilience and future survival of local ecosystems in the face of unpredictable climate scenarios. Partnerships encounter challenges in adapting to these changes while promoting sustainable practices and supporting affected communities	UGGP Model	External/ Treat
SLD	*Sustainable Local Development*	*Local Development*	It represents the process of sustainable economic, social and ecological improvement in a specific geographic area	UGGP Model	Objective

Table A2 – SWOT Sor Matrix

		O1	O2	O3	O4	O5		T1	T2	T3	T4	T1	
	Esternal	***Governance***	***Funds***	***Nature***	***Geology***	***Research***	**Row sem-Total**	*Abandonm.*	*Deforest.*	*Outmigr.*	*Incaccess.*	*Climate Change*	**Row Total**
	Internal												
S1	***Conservation***	1	2	2	1	1	*7*	0	1	2	0	2	*5*
S2	***Education***	1	2	1	1	2	*7*	0	0	3	1	1	*5*
S3	***Activities***	1	2	0	0	2	*5*	2	1	2	0	2	*7*
S4	***Action***	2	2	1	0	1	*6*	1	1	2	1	1	*6*
S5	***Knowledge***	1	2	2	1	2	*8*	1	1	1	0	1	*4*
	Column total	*6*	*10*	*6*	*3*	*8*		*4*	*4*	*10*	*2*	*7*	
						Quadrant I total	**33**					*Quadrant II total*	**27**
W1	***Participation***	1	1	1	1	2	*6*	1	1	2	0	2	*6*
W2	***Entrepreneurship***	2	2	1	1	1	*7*	0	1	3	0	1	*5*
W3	***Awareness***	1	1	2	1	1	*6*	2	2	0	0	2	*6*
W4	***Information***	2	2	2	1	2	*9*	0	1	0	0	2	*3*
W5	***Sustainable Tourism***	0	0	2	0	1	*3*	2	1	3	2	1	*9*
	Column total	*6*	*6*	*8*	*4*	*7*		*5*	*6*	*8*	*2*	*8*	
						Quadrant III total	**31**					*Quadrant IV total*	**29**

Table A3 – FCMs Matrix

Cod.	Variables	S1	S2	S3	S4	S5	W1	W2	W3	W4	W5	O1	O2	O3	O4	O5	T1	T2	T3	T4	T5	OBJ
S1	*Conservation*						0	0	0	0	0	1	2	2	1	1	0	-1	-2	0	-2	0
S2	*Education*						0	0	-1	0	-1	1	2	1	1	2	0	0	-3	-1	-1	0
S3	*Activities*						0	0	0	0	-1	1	2	0	0	2	-2	-1	-2	0	-2	2
S4	*Action*	1					0	0	0	0	-2	2	2	1	0	1	-1	-1	-2	-1	-1	1
S5	*Knowledge*	2	2				0	0	0	0	0	1	2	2	1	2	-1	-1	-1	0	-1	0
W1	*Participation*	0	0	0	0	0			1			-1	-1	-1	-1	-2	1	1	2	0	2	0
W2	*Entrepreneurship*	0	0	-3	0	0					2	-2	-2	-1	-1	-1	0	1	3	0	1	0
W3	*Awareness*	-3	0	0	0	0					2	-1	-1	-2	-1	-1	2	2	0	0	2	0
W4	*Information*	0	-1	0	0	0			2		2	-2	-2	-2	-1	-2	0	1	0	0	2	0
W5	*Sustainable Tourism*	0	0	-2	0	0						0	0	-2	0	-1	2	1	3	2	1	-2
O1	*Governance*	1					-2			-2												
O2	*Funds*	2			3																	2
O3	*Nature*										-1										-1	
O4	*Geology*										-1											
O5	*Research*	1							-1			1		1	1							
T1	*Abandonment*					-1																
T2	*Deforestation*	-3												-2	-1							
T3	*Outmigration*			-2		-1		2									2					-2
T4	*Incaccessibility*																					
T5	*Climate Change*																					
OBJ	*SLD*																					

General Conclusions

Backround

This research provides valuable insights into the potential of the UNESCO Global Geopark (UGGP) model as a possible development strategy for marginalised areas, focusing on the case study of Gargano in the Puglia Region in the South of Italy.

Place-based approaches and tailored solutions are essential for fostering sustainable development in peripheral and marginalised rural areas. These development strategies valorise local assets, enhance social cohesion, and increase communities' capacities to handle the social, economic, and ecological challenges they face, strengthening the local system's resilience. This thesis explores the potential of the UGGP model as a possible sustainable development strategy for Gargano, renowned for its biodiversity, cultural heritage, and geological diversity. Notwithstanding its unique social, cultural, and natural capital, Gargano struggles with persistent socio-economic challenges and environmental degradation compounded by a lack of social cohesion.

Main findings

The thesis has been carried out in several steps. First, key stakeholders of the area have been identified using Stakeholder Network Analysis (SNA) in paper no. 1 titled: 'Stakeholder Empowerment in Sustainable Rural Development Partnerships: Two Case Studies from Italy' and published in Sustainability journal on April 21, 2023.Main findings include disparities in stakeholder empowerment in study area with economic associations dominating decision-making, reflecting the region's agriculture-based economy. The analysis was carried out with comparative method where more developed area from the North of Italy, Veneto has been chosen to be examined. Veneto demonstrated a more balanced distribution of power, fostering inclusivity but facing coordination

challenges. These findings underscore the importance of adapting partnership strategies to regional contexts to enhance stakeholder representation and collaboration.

The second step was to understand rural transformations and development patterns of Gargano as illustrated in paper no. 2 titled 'Key Drivers of Land Use Changes in the Rural Area of Gargano (South Italy) and Their Implications for the Local Sustainable Development' and published in Land journal on 31 January 2024. These findings highlight both opportunities and challenges for sustainable development, emphasizing the need for ad hoc strategies to balance urbanization pressures and ecological conservation.

Based on these two preparatory studies, the final step, through paper no. 3 titled 'The UNESCO Global Geopark Model for Sustainable Development in Marginalised Areas: Modeling Perceptions and Social Acceptance in a Local Context' and submitted to the peer-reviewed journal *Ecological Economics* aimed to analyse if UGGP is an ad-hoc development strategy to capture the local stakeholders' perceptions.

The findings reveal that, while the UGGP model holds significant promise for enhancing sustainable development, local stakeholders often perceive its elements as less effective compared to more tangible, locally-driven interventions. This underscores the need for a dual strategy: prioritizing widely accepted development drivers, while simultaneously fostering awareness among local stakeholders of the UGGP's benefits and potential synergies with existing local development initiatives. Key findings include leveraging local knowledge and entrepreneurial mindsets to enhance the UGGP model's social acceptance while addressing the untapped potential of UGGP policies through complementary strategies. Specific initiatives, such as education on geological heritage and awareness campaigns for conservation, were noted as critical yet complementary components of a broader development strategy.

The analysis highlights a methodological gap in integrating stakeholder perceptions with UGGP-specific drivers and contributes to the academic discourse on sustainable development frameworks. The study emphasizes the importance of aligning UGGP initiatives with local priorities set by

stakeholders, ensuring their long-term viability and success. Moreover, strengthening stakeholder participation and implementing targeted awareness campaigns are crucial for fostering support and unlocking the full potential of the UGGP model.

Limitations and future prospects

Despite a large mobilization of stakeholders, only few accepted to be interviewed. This potentially leads to the underrepresentation of some categories of stakeholders representing the main limitation of this study. Future research should consider expanding the number of respondents and to balance the categories' representation in order to provide some validation to these findings.

To build on these findings, further research should focus on exploring synergies between local development drivers performing further FCMs simulation. But a major research avenue is examining how the perception of UGGP policies evolves over time in response to awareness campaigns, stakeholder involvement, and successful interventions, while assessing the effects of combining UGGP-specific drivers with well-established development drivers on policy success and community commitment. Developing and testing indicators to measure the effectiveness of UGGP-related interventions in raising policy acceptability and achieving tangible development outcomes would also be highly beneficial. Such indicators could be compared across different regions or contexts to better understand the variability of UGGP impacts and identify scalable solutions

In conclusion, this thesis contributes to the academic discourse on sustainable development frameworks by demonstrating the applicability of the UGGP model in a complex socio-ecological context. It provides actionable recommendations for policymakers and practitioners to align UGGP initiatives with local priorities, ensuring their long-term viability and success. Future research should focus on longitudinal studies to track the evolution of stakeholder perceptions and the effectiveness of UGGP policies over time. Additionally, comparative analyses across different regions and contexts can identify scalable solutions and best practices, further enhancing the global impact of UNESCO Global Geoparks on local sustainable development.

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